AFRL-HE-WP-TR-2003-0099

United States Air Force Research Laboratory

Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) Field Demonstration Report: IRP Site 4, POL Area, Springfield ANG Base, Springfield, Ohio

Dennis A. Reed
Teresa R. Sterner
John S. Sarson

OPERATIONAL TECHNOLOGIES CORPORATION
1370 N. FAIRFIELD ROAD, SUITE A
BEAVERCREEK, OH 45432

May 2003

FINAL REPORT FOR THE PERIOD MAY 2002 TO DECEMBER 2002

Approved for public release; distribution is unlimited

Human Effectiveness Directorate
Biosciences and Protection Branch
Applied Toxicology Branch
Wright-Patterson AFB OH 45433-7400

NOTICES

When US Government drawings, specifications or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Please do not request copies of this report from the Air Force Research Laboratory. Additional copies may be purchased from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Federal Government agencies and their contractors registered with the Defense Technical Information Center should direct requests for copies of this report to:

Defense Technical Information Service
8725 John J. Kingman Rd., Ste 0944
Ft. Belvoir, Virginia 22060-6218

DISCLAIMER

This Technical Report is published as received and has not
been edited by the Technical Editing Staff of the Air Force Research Laboratory.

TECHNICAL REVIEW AND APPROVAL

AFRL-HE-WP-TR-2003-0099

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE DIRECTOR

//SIGNED//

MARK M. HOFFMAN
Deputy Chief, Biosciences and Protection Division
Air Force Research Laboratory

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	May 2003	Final Report - May 2002- December 2002

4. TITLE AND SUBTITLE

Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) Field Demonstration Report: IRP Site 4, Pol Area, Springfield Ang Base, Springfield, OH

5. FUNDING NUMBERS

Contract #F33601-02-F-A211
PE 62202F
PR 1710
TA 1710D
WU 1710D408

6. AUTHOR(S)

*Reed, Dennis A; Sterner, Teresa R; Sarson, John S.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

*Operational Technologies Corp.
Dayton, OH

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Human Effectiveness Directorate
Air Force Research Laboratory
Wright-Patterson AFB, OH 45433-5707

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

AFRL-HE-WP-TR-2003-0099

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

A demonstration of the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) approach for assessing human health risk at weathered petroleum release sites was performed at a petroleum, oil and lubricant underground storage tank site (JP-4 and JP-8) located at the Springfield Air National Guard Base, Springfield, Ohio. A total of nine subsurface soil samples were obtained for this demonstration project at subsurface depths ranging from 4 to 6 feet. Soil analyses included both volatile and extractable petroleum hydrocarbons using the TPHCWG direct method and the Massachusetts Department of Environmental Protection (MA DEP) methodology to compare the approaches. Soil core composites were analyzed for trichloroethylene, gasoline-range organics, volatile petroleum hydrocarbons, benzene, toluene, ethylbenzene, and xylenes (BTEX), diesel-range organics, polycyclic aromatic hydrocarbons, and extractable petroleum hydrocarbons using both the TPHCWG and MA DEP protocols. No benzene or trichloroethylene was detected and only trace concentrations of toluene, ethylbenzene and xylenes were detected. Results, in combination with the finding of very low concentrations of BTEX, indicated that the hydrocarbons detected in site soils were composed of a weathered petroleum mixture. Overall, the TPHCWG approach provides better insight into the nature of petroleum hydrocarbon contamination (i.e., it provides more robust fractional analysis data) and is less likely to overestimate the risk posed to human receptors under the same exposure scenario.

14. SUBJECT TERMS		15. NUMBER OF PAGES
Aliphatic hydrocarbons	Diesel Range Organics (DRO)	99
Direct method	Jet Fuel	16. PRICE CODE
Gasoline Range Organics (GRO)		

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

THIS PAGE INTENTIONALLY LEFT BLANK.

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK.

LIST OF TABLES

Page

LIST OF FIGURES

LIST OF APPENDICES

THIS PAGE INTENTIONALLY LEFT BLANK.

PREFACE

This demonstration project was performed by Operational Technologies Corporation (OpTech) under Contract Number F33601-02-F-A211. OpTech activities were conducted under the Project Management of Dr. Peter Lurker, 1370 North Fairfield Road, Suite A, Beavercreek, OH 45432. Dr. David Mattie of the Air Force Research Laboratory, Human Effectiveness Directorate, Operational Toxicology Branch (AFRL/HEST) at Wright-Patterson Air Force Base (AFB), OH, served as contract monitor.

The authors of this report gratefully acknowledge Mr. Joe Fleck of Enviro Core, Ltd., for operating the Geoprobe™ direct-push sampling equipment and obtaining the soil sample cores. We also acknowledge the technical assistance provided by Mr. Richard Entz of Lancaster Laboratories, Lancaster, PA, for his guidance on analytical methods for petroleum hydrocarbons and for interpreting the inconsistencies noted in the analytical data. Our special thanks go to Captain Vincent Roberts, Environmental Manager, and Mr. Richard Cisler, Environmental Specialist, 178th Fighter Wing, SANGB, for their assistance in arranging site access for this field demonstration. Without the outstanding support that was provided by these people, this demonstration project would not have been possible.

THIS PAGE INTENTIONALLY LEFT BLANK.

TOTAL PETROLEUM HYDROCARBON CRITERIA WORKING GROUP (TPHCWG) FIELD DEMONSTRATION REPORT: IRP SITE 4, POL AREA, SPRINGFIELD ANG BASE, SPRINGFIELD, OHIO

EXECUTIVE SUMMARY

A demonstration of the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) approach for assessing human health risk at weathered petroleum release sites was performed at a petroleum, oil and lubricant (POL) underground storage tank site located at the Springfield Air National Guard Base (SANGB), Springfield, Ohio. The demonstration site is contaminated with "weathered" jet fuel (JP-4 and JP-8). The maximum total petroleum hydrocarbon (TPH) concentrations detected during a 1992 investigation were 1520 mg of gasoline range organics (GRO) per kg of soil and 131 mg/kg diesel range organics (DRO). This TPH contamination was detected in a soil sample obtained at a depth of 4 to 6 feet below ground surface (bgs).

A total of ten subsurface soil samples (nine primary samples and one duplicate sample) were obtained for this demonstration project using direct-push sampling equipment. Sampling depths ranged from 4 to 6 feet bgs. Soil samples were selected for laboratory analysis based upon photoionization detector (PID) readings of sample cores. A background sample in an area known to be upgradient of the petroleum contamination was also obtained for laboratory analysis. Composited samples were analyzed for volatile components including trichloroethylene (TCE), volatile petroleum hydrocarbon (VPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX). Composite samples were also analyzed for DRO, polycyclic aromatic hydrocarbons (PAHs) and for aliphatic and aromatic hydrocarbon fractions using both the TPHCWG and Massachusetts Department of Environmental Protection (MA DEP) protocols.

Benzene and TCE were not detected in any of the samples collected for this demonstration project. Only trace concentrations of toluene, ethylbenzene and xylenes were detected and only two PAHs (naphthalene and 2-methylnaphthalene) were detected above method detection limits. TPH GRO and TPH DRO were detected in all nine of the primary soil samples. TPH GRO concentrations ranged from 9.1 mg/kg to 270 mg/kg. TPH DRO concentrations ranged from 22 mg/kg to 360 mg/kg. The highest concentration of TPH (GRO + DRO) was 560 mg/kg. Seven of the nine soil samples contained TPH at concentrations above the minimum threshold (approximately 100 mg/kg) required to support fractional analysis by the direct method. Most TPHs detected were aliphatic hydrocarbons in the EC>8 –10 and EC>10-12 fractions. Very low concentrations of light aliphatic hydrocarbons and only trace concentrations of light aromatic hydrocarbons were detected. The aliphatic and aromatic fractions detected using the MA DEP analytical methodology also indicate that the TPH in SANGB POL area soils is predominately composed of aliphatic hydrocarbons in the C9–12 fraction. No aliphatic hydrocarbons were detected in the C19–36 fraction and only a few samples were found to contain any aromatic hydrocarbons in the C11-22 fraction. These results, in combination with the finding of very low concentrations of BTEX, indicated that the TPH detected in site soils is composed of a weathered petroleum mixture.

An analysis of the analytical data showed that the TPHCWG fractional analysis results tended to underestimate the total TPH (GRO + DRO) detected in site soils, due to significant

matrix effects seen in quality control spiked soil analyses. The MA DEP fractional analysis results tended to overestimate the total TPH. The underestimation of TPH using the Working Group methodology and the overestimation of TPH using the MA DEP methodology was particularly evident in sample number IRP4B08S5-6P (and its duplicate, IRP4B10S5-6P). Most of the overestimation by the MA DEP methodology is probably attributable to "double addition" that results from the overlap between the C9-12 (VPH) aliphatic fraction and the C9-18 (EPH) aliphatic fraction. Most of the underestimation by the TPHCWG methodology is probably the result of poor recoveries of petroleum hydrocarbons from the soil matrix.

Field screening data obtained with a portable PID were collected immediately above the soil cores. With the exception of the PID readings obtained for sample numbers IRP4B04S5-6P and IRP4B08S5-6P, there was generally good agreement between the field screening results and the total TPH (GRO + DRO) detected in the soil samples collected for this demonstration project. Overall, there was also relatively good agreement between the petroleum odor noted by the sampling team and the PID readings.

The analytical data were subjected to a first order "fingerprint" analysis. The analysis was performed using the five samples that contained the highest concentrations of TPH (GRO + DRO). These five samples were IRP4B03S5-6P, IRP4B08S5-6P, IRP4B09S5-6P, IRP4B10S5-6P (duplicate) and IRP4B12S5-6P. For these five samples, the weight percent of aliphatic fractions ranged from 74.05% to 83.92% using the TPHCWG methodology, and from 77.8% to 81.3% using the MA DEP methodology. The weight percent of aromatic fractions ranged from 16.08% to 25.95% using the TPHCWG methodology and from 18.7% to 22.2% using the MA DEP methodology. The average weight fractions of the heavier aliphatic and aromatic hydrocarbons was 65.98% for the TPHCWG fractions and 63.34% for the MA DEP fractions compared to an average weight percent of 55.3% for DRO. There was also good agreement between the average weight fractions of the lighter aliphatic and aromatic hydrocarbons and the average weight percent of GRO (33.90% vs. 44.7% for the TPHCWG fractions and 36.6% vs. 44.7% for the MA DEP fractions).

Among the direct and indirect soil exposure pathways, the subsurface soil indoor vapor inhalation pathway consistently contained the lowest total TPH RBSLs. For this pathway, all ten samples exceeded their respective total TPH RBSLs using the MA DEP fractions and seven of the ten samples exceeded their respective total TPH RBSLs using the TPHCWG fractions. For the subsurface soil outdoor vapor inhalation pathway, none of the samples analyzed for the TPHCWG fractions contained TPH at a concentration that exceeded any of the fraction-specific RBSLs. However, five of the ten samples analyzed for the MA DEP fractions exceeded the fraction-specific RBSL for the C5-8 aliphatic fraction. This significant difference in risk was expected because the MA DEP reference concentration (RfC) for this fraction is nearly two orders of magnitude lower than the TPHCWG RfC (0.2 mg/m^3 vs. 18.4 mg/m^3).

Total TPH concentrations across the TPHCWG and MA DEP fractions compare reasonably well with the total TPH (GRO + DRO), although the MA DEP methodology appears to overestimate TPH concentrations to a greater extent than the TPHCWG approach underestimates the TPH concentrations in site soils. Both approaches provide fractional analysis data that give essentially the same TPH "fingerprint". Both approaches also provide fractional analysis data that can be used within the RBCA framework to assess the risk posed to potential human receptors by petroleum hydrocarbon contamination in site soils. However, the TPHCWG approach provides better insight into the nature of petroleum hydrocarbon contamination (i.e., it provides more robust fractional analysis data) and is less likely to overestimate the risk posed to human receptors under the same exposure scenario.

TOTAL PETROLEUM HYDROCARBON CRITERIA WORKING GROUP (TPHCWG) FIELD DEMONSTRATION REPORT: IRP SITE 4, POL AREA, SPRINGFIELD ANG BASE, SPRINGFIELD, OHIO

1.0 INTRODUCTION

The Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) has developed an approach for establishing soil clean-up criteria, which is protective of human health at petroleum release sites. This approach treats complex petroleum mixtures as a combination of hydrocarbon fractions for conducting environmental modeling and estimating non-cancer risk. Carcinogenic petroleum compounds must be evaluated separately (Vorhees *et al.*, 1999). The TPHCWG approach can be used within a tiered framework to estimate human health risk and to calculate Risk-Based Screening Levels (RBSLs). The TPHCWG approach is consistent with U.S. Environmental Protection Agency (USEPA) guidance and the American Society for Testing and Materials (ASTM) E 1739 – 95, "Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites" (RBCA).

Simultaneously, the Massachusetts Department of Environmental Protection (MA DEP) published a new toxicological approach to characterize and evaluate risks posed by petroleum-contaminated sites in order to address shortcomings in traditional TPH methods that provide little or no information on the composition or toxicity of petroleum contamination. MA DEP developed two analytical methods to separate and quantitate aliphatic and aromatic hydrocarbon concentrations in soil and water. MA DEP developed soil and groundwater cleanup standards for the aliphatic and aromatic ranges of interest, which became effective in 1997 (MA DEP, 2002).

A petroleum, oil and lubricant (POL) underground storage tank (UST) site located at the Springfield Air National Guard Base (SANGB), Springfield, OH, contaminated with "weathered" jet fuel (JP-4 and JP-8), was selected for demonstration of the TPHCWG approach. This site was chosen because at least one major fuel spill was known to have occurred (SAIC, 1995). Field sampling activities were conducted on December 9, 2002 in accordance with a work plan prepared by Operational Technologies (OpTech) Corporation (Reed, 2002). Soil samples collected under this work plan were shipped to Lancaster Laboratories, Lancaster, PA, for TPH fractional analysis using the TPHCWG approach and the MA DEP methodology.

1.1 The objectives of this project were as follows:

- To effectively demonstrate the utility of the TPHCWG fractional analysis approach in TPH contaminated soil, regardless of fuel type, soil type, contaminant history or environmental setting.
- To provide additional data on the characteristics of weathered petroleum products in soil to support the development of a cost-effective site assessment program using the RBCA decision making process.
- To compare total petroleum hydrocarbon (TPH) fractional analysis data and RBSLs between the TPHCWG and MA DEP methodologies.

1.2 Site Background and Previous Sampling Results

The POL facility and surrounding area was investigated under the Installation Restoration Program (IRP) as IRP Site Number 4 in 1992 by Science Applications International Corp. (SAIC). The results of this investigation were documented in the "Final Site Investigation Report for the Ohio Air National Guard, 178th Fighter Group, Springfield-Beckley Municipal Airport, Springfield, Ohio" (SAIC, 1995). This site was subsequently included in a remedial investigation (RI) that was performed by Montgomery Watson. Results of the RI are documented in Volume 1 of the Final Remedial Investigation Report for the 178th Fighter Wing, Ohio Air National Guard Base, Springfield, Ohio" (Montgomery Watson, 1999). Native Energy and Technology, Inc., conducted a third investigation of IRP Site 4 in 2001. The results of this investigation are documented in the "Draft Site Assessment Report for Building 106 Gravel Area, 178th Fighter Wing, Ohio Air National Guard, Springfield Air National Guard Base, Springfield-Beckley Municipal Airport, Springfield, Ohio" (NETI, 2002). On the basis of these investigations, the highest petroleum hydrocarbon contamination in site soils is located within a relatively small area immediately west of the oval asphalt track that contains the jet fuel USTs. The maximum TPH concentrations detected in this area were 1520 mg of gasoline range organics (GRO) per kg of soil and 131 mg/kg diesel range organics (DRO). This TPH contamination was detected in a soil sample obtained at a depth of 4 to 6 feet below ground surface (bgs), during the RI that was performed by SAIC (1995).

2.0 SITE SAMPLING AND ANALYSIS ACTIVITIES

A systematic sampling strategy was employed to obtain nine primary and one duplicate soil samples from locations within the petroleum release site where subsurface concentrations of petroleum hydrocarbons were known to be at or near their maximum values. Results from previous site investigations (Montgomery Watson, 1999) indicated that maximum concentrations of petroleum hydrocarbons were likely to be found along and to either side of a line between the sump pumping station (facility number 115) and monitoring well number MW4-1 (see Figure C-1, Appendix C). Subsurface soil samples were obtained by advancing sleeves using direct-push sampling equipment (see Figure C-2, Appendix C). The maximum soil sampling depth was 6 feet bgs. Soil samples were selected for laboratory analysis based upon photoionization detector (PID) readings of sample cores. A background sample in an area known to be upgradient of the petroleum contamination was also obtained for laboratory analysis.

2.1 Soil Sampling

A total of ten soil samples (nine primary and one duplicate) were collected along and perpendicular to a line connecting the sump pumping station and monitoring well number MW4-1 (see Figure 2-1). Soil samples were collected in 2" diameter Teflon™ sampling sleeves using a Geoprobe™ direct-push sampling system that was operated by Enviro Core, Ltd. Soil samples were collected in three-foot sampling intervals bgs until groundwater was encountered. The soil sample cores were field screened using a Mine Safety Appliances Passport PLD portable PID, serial number 12924. The PID was rented from Total Safety, Inc. (Dayton, OH). The instrument was calibrated on the day of sampling by Total Safety, Inc., using 100 ppm isobutylene gas. The field sampling team performed a functional test of the PID using petroleum vapors (gasoline) prior to use.

Foot long segments of the 2" soil sample cores exhibiting the highest PID readings were composited to prepare the required sample volumes for subsequent laboratory analysis. The majority of samples were taken five to six feet bgs. A copy of the field sample log is shown in Table C-1, Appendix C. A background soil sample from a pre-selected site upgradient from the target sampling area was also obtained. This background sample was collected using the same direct-push sampling method employed to obtain the primary samples. The sample depth was determined by calculating the average depth (approximately 5 feet bgs) of the primary soil sample cores exhibiting the highest PID readings. A copy of the field sample summary is shown in Table C-2, Appendix C.

2.2 Field Quality Control Samples

A field duplicate sample set was collected from boring number IRP4B08 and marked as IRP4B10. The duplicate was submitted blind to the laboratory to evaluate laboratory precision, accuracy and repeatability. Rinsate blanks were collected on two occasions from the split spoon and stainless steel bowl as they were rinsed with deionized water at the conclusion of the decontamination process. These rinsate blanks were collected to evaluate the effectiveness of equipment decontamination procedures that were used in the field. In addition, a water blank was filled directly from one of the commercially purchased jugs of deionized water to ensure no volatile hydrocarbons were inadvertently introduced during sample collection activities. Water samples were collected in 40 mL glass vials preserved with hydrochloric acid; liquid samples were filled to a positive meniscus, capped and inverted to ensure there were no bubbles. A copy of the field log for QA/QC samples is shown in Table C-3, Appendix C. Pre-labeled trip blanks from Lancaster Laboratories accompanied samples at the site and during return shipment to the laboratory. A temperature blank prepared by Lancaster Labs was returned with the samples to determine if the arrival temperature met the goal of $4 \pm 2°C$. A double set of soil samples was sent from boring number IRP4B16 (background site) for matrix spike and matrix spike duplicate analyses.

2.3 Field Sample Identification

Each sample collected by the field sampling team was assigned a unique sample identification code and labeled accordingly. The first four digits of the code contained the IRP program site number (i.e., IRP4). The next three characters in the code included B (for borehole) and NN (the sequential number assigned). The next character indicated the sample matrix (i.e., S for soil). The next set of numbers indicated the depth (bgs) of the soil sampling interval (e.g., 5-6 feet) and the final set of characters indicated the field sample type where P = primary sample, EB = equipment blank and FD = field duplicate. Pre-labeled sampling jars provided by the analytical laboratory were used for all samples collected for this demonstration project.

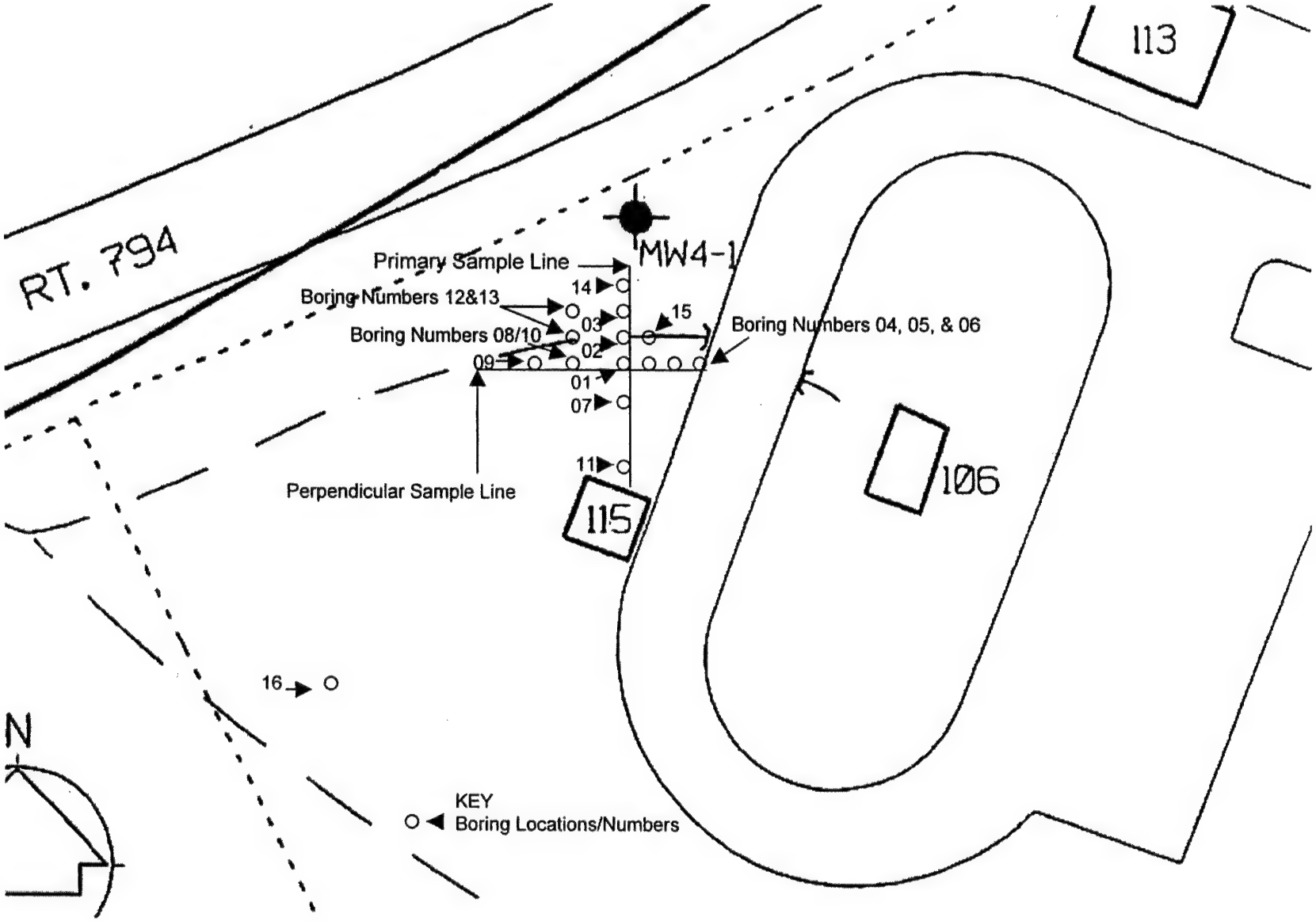

Figure 2-1 Soil Boring Locations/Numbers, SANGB POL Area

2.4 Sample Packaging and Shipping

Gallon bags of wet ice were placed in the cooler below heavy cardboard dividers provided by Lancaster Laboratories. Samples were placed in prefabricated cardboard slots within the shipping coolers and foam disks were inserted between jars for protection and limitation of movement during shipment. Glass vials were inserted into slots in foam blocks provided for the purpose. Bubble wrap was laid on top of the samples and bags of wet ice were placed around and on top of the samples to maintain a temperature of $4 \pm 2^{\circ}C$. Completed chain-of-custody forms were placed in resealable plastic bags and secured inside the coolers. Each shipping cooler was sealed with chain-of-custody tape on the front right corner. Clear packing tape was placed around each cooler using a minimum of two full wraps.

2.5 Field and Sample Custody Documentation

Field notes were recorded in a three-ring notebook on pre-formatted field sample log forms. Notes included:

- PID readings (sample core and head space in sample bag, in ppm)
- Borehole location, number and depth
- Sample core information (PID reading, time PID reading taken, soil appearance including color/staining and odor, and the depth interval of sample collection)
- Sequence of water and rinsate blanks taken
- Number of feet penetrated bgs

2.6 Equipment Decontamination

Sampling tools were decontaminated by first scrubbing with a brush in clean water, followed by scrubbing in an Alconox solution and rinsing in clean water. Finally, the tools were rinsed with deionized water. Tools decontaminated in this manner included the soil sampling probes, the stainless steel scoop and the stainless steel mixing bowl. Personnel performing decontamination wore nitrile gloves under clean, chemical resistant waterproof gloves.

2.7 Disposition of Investigation Derived Waste (IDW)

All soil cores, including residual sampling cores and cores not used for sampling were placed in a 55 gallon resealable drum for disposal as IDW. Wash and rinsate water was contained separately in a second 55 gallon resealable drum. Both drums were labeled as required by the 178th Environmental Management Section, SANGB. Both drums were transported to a staging facility for subsequent disposition of IDW. Disposable personal protection equipment (Tyvek suits, gloves) and sampling wastes (soiled resealable bags, Teflon sampling sleeves, and paper towels) were also placed in the second drum for disposal as non-hazardous waste.

2.8 Laboratory Analysis

Foot-long segments selected for sampling, as indicated by PID readings and soil characteristics (i.e., stains and odors), were composited in a stainless steel bowl using a

stainless steel scoop. Soil was packed into glass sampling jars with Teflon™-lined lids and shipped via overnight delivery to Lancaster Laboratories, Lancaster, PA, for analysis. The volatile analyses were trichloroethylene (TCE), GRO, volatile petroleum hydrocarbons (VPH) and benzene, toluene, ethylbenzene and xylenes (BTEX). Samples also were analyzed for DRO, polycyclic aromatic hydrocarbons (PAHs) and for aliphatic and aromatic hydrocarbon fractions using both the TPHCWG and MA DEP protocols.

Under the TPHCWG Direct Method, soil composite samples were analyzed for aliphatic and aromatic semivolatiles (EC>8-35 range) using a simple extraction with pentane followed by the fractionation of aliphatics and aromatics on a silica gel column (modified USEPA Method 3630C). A gas chromatograph (GC) with a flame ionization detector (FID) was used to analyze the different fractions under Lancaster Laboratory's Protocol 1. The separation procedure was performed using silica gel to fractionate petroleum compounds into saturates, aromatics and polars. A 2:3 mixture of methylene chloride and pentane was used for elution of aromatics from the silica gel. In addition, an alternative gas chromatographic column (same phase type) was used along with different flow rates and temperature programming to detect aromatic compounds that elute earlier than C8 n-alkanes as well as C26 to C35 hydrocarbons. Direct injection techniques and use of hydrogen carrier gas were employed to provide resolution and to limit potential mass discrimination over the working range (C>8 to C35 normal hydrocarbons) (Weisman, ed., 1998).

Analysis for aliphatic and aromatic volatiles (equivalent carbon (EC) range EC5-8) was performed using the Lancaster Laboratory's Protocol 2. This protocol was a modification of the "Method for the Determination of Volatile Petroleum Hydrocarbons" (MA DEP, 1998a) and the Washington Department of Ecology (WDE) method for the determination of VPH fractions (WDE, 1997). Protocol 2 used purge and trap gas chromatography with PID and FID detectors. Because n-pentane was used for extraction with this protocol, retention times for the petroleum fractions started at the end of the n-pentane peak (Weisman, ed., 1998).

Instrument calibration for Protocol 1 was based on the average response for the following normal alkanes: C8, C10, C12, C16, C20, C22 and C32. Mass discrimination was controlled such that the average response for each target alkane did not vary by more than 15% from the overall average alkane response. For Protocol 2, calibration of EC5-6 aliphatics was determined based on the response of 2-methylpentane and EC>6-8 aliphatics are based on n-heptane response. This deviated from the WDE method in that the averaged response for n-pentane and n-hexane defined the first respective range and n-octane defined the second range (Weisman, ed., 1998). The MA DEP method defined the ranges differently (C5-8) and used the average response for n-pentane, 2-methylpentane and 2,2,4-trimethylpentane (MA DEP, 1998a).

The MA DEP approach used two distinct analytical protocols to analyze petroleum hydrocarbons in water and soil: the VPH protocol for light aliphatic and aromatic fractions; and the extractable petroleum hydrocarbons (EPH) protocol for the medium to heavy aliphatic and aromatic fractions. Under the VPH protocol, gasoline-range volatile hydrocarbons in soil and water were analyzed by GC coupled to a purge and trap concentration system. The method was capable of detecting C5-11. Detection was achieved by using a PID in series with a FID. Quantitation was done by comparing the area under the chromatogram from the appropriate FID or PID response to the corresponding response of a volatile petroleum hydrocarbon standard (MA DEP, 1998a). Under the EPH protocol, extractable hydrocarbons corresponding to carbon number ranges of approximately C10-32 were measured in soil and water samples. Samples were spiked with a surrogate compound (used to monitor extraction efficiency) and

extracted with methylene chloride. Analysis was performed on a GC equipped with a FID and a PID in series. Quantitation was accomplished by comparing the area under the chromatogram from the appropriate FID or PID response of a sample to the corresponding response of a standard mixture containing the compounds of interest (MA DEP, 1998b).

3.0 WORKING GROUP APPROACH FOR TIER 1 ASSESSMENTS

3.1 Identification of Exposure Scenarios

A complete exposure scenario includes a source of contamination, a transport mechanism, an exposure pathway and a receptor. For this project it was assumed that contaminants present in surface and subsurface soils are transported via wind erosion, by volatilization to indoor and outdoor air, and by leaching to groundwater. Because the POL area is located at an active military facility, it was assumed that commercial/industrial receptors exist at the site. Residential receptors were not considered because the site is unlikely to be developed as a residential area in the foreseeable future. The soil leaching to groundwater pathway was also not evaluated because the groundwater resource at the site is not presently a source of drinking water and it is unlikely to become a source of drinking water in the foreseeable future. Consequently, the following exposure scenarios were evaluated in Tier 1:

- Direct contact with surface soils by commercial/industrial receptors
- Inhalation of indoor (nearby buildings) air by commercial/industrial receptors
- Inhalation of outdoor (on-site) air by commercial/industrial receptors

3.2 Calculation of Tier 1 RBSLs

Tier 1 RBSLs were calculated using a procedure developed by the TPHCWG, which is based upon the standard default equations and geological factors used in the ASTM RBCA process (ASTM, 1995). This procedure differs from the RBCA framework in that it considers additivity of risk. Additivity of risk is usually not considered in a Tier 1 evaluation because RBSLs are generally developed for a limited number of constituents. However, because TPH is a complex mixture, the approach used to calculate TPH RBSLs differs from that used for individual chemicals of concern. Evaluating TPH as a mixture is also important for assessing interactions between different individual chemicals or fractions that impact fate and transport modeling. The TPHCWG RBSL calculations use Raoult's Law to simplify the true behavior of chemicals in a mixture (i.e., assumes ideal solution behavior) (Vorhees *et al.*, 1999). Consequently, the actual vapor pressure of the complex TPH mixture may be higher or lower, depending upon the strength of the intermolecular bonds (Perry and Chilton, eds., 1973). (Note: To obtain the actual vapor pressure of a complex mixture, the activity coefficients for each constituent must be calculated from physical chemical data (if available) applicable to the conditions (i.e., temperature and pressure) under which the risk estimate is to be calculated.)

To incorporate the concept of risk additivity into the calculation of a RBSL for the TPH mixture, hazard quotients (HQs) are calculated for each TPH fraction. Rather than compare each individual HQ to an acceptable value of 1.0, the sum of all the HQ values is calculated to derive the overall hazard index (HI). This HI for the entire TPH mixture (i.e., all fractions combined) is compared to the acceptable risk level of 1.0 (Vorhees *et al.*, 1999).

Another important consideration in the RBSL calculation is an upper exposure limit for cross media pathways, such as soil leaching to groundwater or volatilization to indoor or outdoor air. This upper limit, the chemical saturation concentration (C_{sat}), is the soil concentration at which the sorption limits of the soil particles, the solubility limits of the soil pore water and the saturation limit of the soil pore air have been reached. C_{sat} is not equivalent to the concentration at which free product is observed; it is an upper limit for transport of petroleum fractions in cross-media pathways. A similar and related term is residual saturation (RES). When calculating RBSLs, a value of RES means that the selected risk level (e.g., HI = 1.0) could not be reached or exceeded for the pathway and scenario given the constituents present, regardless of the contaminant concentration. The value of RES is attained at the TPH concentration at which the C_{sat} of the mixture is reached (i.e., each fraction has reached C_{sat}). When calculating the whole TPH RBSL, a value of RES indicates that even if the concentration of each fraction is set equal to C_{sat} for that fraction and pathway, the combined risk associated with each fraction still does not yield a HI of 1.0. It is important to note that C_{sat} is not an appropriate constraint for the direct contact pathway because the exposure is to the contaminated soil and not to a medium to which the soil contamination has been transferred. Although C_{sat} may limit exposure for this pathway, not using C_{sat} to limit exposure adds further conservatism to the risk calculation (Vorhees *et al.*, 1999).

3.3 RBSL Calculation Procedures

As stated above, RBSLs for each TPH fraction and each pathway are calculated using standard RBCA default equations (ASTM, 1995). The fraction-specific fate and transport data are presented in Table 3-1 below, and the toxicity data are presented in Tables 3-2 and 3-3 below. The procedure for calculating TPH RBSLs for cross-media pathways based upon summing the risk from each fraction is somewhat more complex.

Table 3-1: Hydrocarbon Fractions and Associated Properties[1]

TPH Fractions	Solubility (mg/L)	Henry's Constant[2] (dimensionless)	Vapor Pressure (atm)	Log K_{oc} (c/c)	BP (°C)	MW (g/mole)
Aliphatic						
EC5-6	36	33	0.35	2.9	51	81
EC>6-8	5.4	50	0.063	3.6	96	100
EC>8-10	0.43	80	6.3E-03	4.5	150	130
EC>10-12	0.034	120	6.3E-4	5.4	200	160
EC>12-16	7.6E-4	520	4.8E-5	6.7	260	200
EC>16-21	2.5E-6	4,900	1.1E-6	8.8	320	270
Aromatic						
EC5-7[3]	1.8E+03	0.23	0.13	1.9	80	78
EC>7-8[4]	520	0.27	0.038	2.4	110	92
EC>8-10	65	0.48	6.3E-03	3.2	150	120
EC>10-12	25	0.14	6.3E-4	3.4	200	130
EC>12-16	5.8	0.053	4.8E-5	3.7	260	150
EC>16-21	0.65	0.013	1.1E-6	4.2	320	190
EC>21-35	0.0066	6.7E-4	4.4E-10	5.1	340	240

[1] Values determined from correlation to relative boiling point index and are based on pure compounds; behavior may differ in complex mixtures (Gustafson *et al.*, 1997);
[2] Calculated based on vapor pressure, solubility and molecular weight relationship;
[3] Experimental values for benzene, not from correlation;
[4] Experimental values for toluene, not from correlation
atm = atmospheres, BP = boiling point, c/c = concentration:concentration ratio, EC = equivalent carbon number, MW = molecular weight

For leaching and volatilization pathways, transport and therefore exposure are maximized at C_{sat} for specific fractions. Using this basis, the HQ for each fraction is calculated as the minimum of two values: (1) the weight percentage of the fraction times the whole TPH RBSL, divided by the fraction RBSL, or (2) C_{sat} for the fraction, divided by the fraction RBSL. The HI is defined as the sum of the HQs for each fraction. Using these calculations, the whole TPH RBSL can be calculated iteratively, under the constraint that the sum of the weight fractions does not exceed 1.0 (Vorhees *et al.*, 1999).

Table 3-2: TPHCWG Toxicity Fraction-Specific RfDs (mg/kg/day) and RfCs (mg/m^3)[1]

Carbon Range	Aromatic RfD and RfC	Critical Effect	Aliphatic RfD and RfC	Critical Effect
EC5-6 EC>6-8	0.20 – Oral[2] 0.4 – Inhalation[2]	Hepatotoxicity, Nephrotoxicity	5.0 – Oral 18.4 - Inhalation	Nephrotoxicity, Hepatotoxicity, Neurotoxicity
EC>8-10 EC>10-12 EC>12-16	0.04 – Oral 0.2 – Inhalation	Decreased body weight	0.1 - Oral 1.0 – Inhalation	Hepatic and hematological changes
EC>16-21 EC>21-35	0.03 - Oral NA - Inhalation	Nephrotoxicity	2.00 NA - Inhalation	Hepatic granuloma

Note: NA = not applicable; RfC = reference concentration; RfD = reference dose
[1] Vorhees *et al.*, 1999.
[2] Excludes EC5-6 as benzene noncancer toxicity was under review by USEPA at the time of publication[1]

Table 3-3: MA DEP Toxicity Fraction-Specific RfDs (mg/kg/day) and RfCs (mg/m^3)[1]

Carbon Range	Aromatic RfD and RfC	Critical Effect	Aliphatic RfD and RfC	Critical Effect
C5-8	Evaluate each chemical in the series separately		0.04 – Oral 0.2 - Inhalation	Neurotoxicity
C9-18	0.03 – Oral 0.05 – Inhalation	Decreased body weight, hepatic, renal and developmental effects	0.1 - Oral 0.2 – Inhalation	Hepatic and hematological changes
C19-32	0.03 – Oral 0.05 - Inhalation		2.00 - Oral NA - Inhalation	Hepatic granuloma

[1] Adapted from MA DEP, 2002.

For direct exposure routes such as soil ingestion, dermal absorption and particulate inhalation, the exposure is not limited by C_{sat} because intake will continue to increase linearly with soil loading beyond C_{sat}. [Note: The presence of non-aqueous phase liquid in the soil is not an issue in a direct contact pathway because the receptor is already directly exposed to the contaminated soil.] In this case, the HQ for each fraction is defined as the weight percentage of the fraction times the whole TPH RBSL divided by the fraction RBSL. The sum of all HQs is equal to the HI for the mixture, which must be less than 1.0 to meet the target risk level (Vorhees *et al.*, 1999). The equations used to calculate the TPH fraction RBSLs and the whole TPH RBSL (C_{TPH}) are provided in Appendix B.

4.0 ANALYTICAL RESULTS

4.1 Analytical Data Summary

A summary of the analytical data for the nine primary soil samples, one duplicate, and one background soil sample collected at the SANGB POL site is shown in Table 4-1. The approximate locations where the soil samples were collected and their respective sample numbers are shown in Figure 2-1. Lancaster Laboratories, under subcontract to OpTech, analyzed all soil samples for BTEX, organic solvents (e.g., TCE), PAHs, TPH-GRO, TPH-DRO, TPHCWG aliphatic and aromatic fractions and MA DEP aliphatic and aromatic fractions.

4.2 BTEX, PAHs and Trichloroethylene

As shown in Table 4-1, no benzene was detected above method detection limits in any of the samples obtained from the SANGB POL area. (Note that nondetects, signified by <###, were set to detection limit, which varied from sample to sample due to moisture content.) Trace concentrations of toluene were found in 4 of the 10 primary samples at concentrations ranging from 163 μg per kg soil to 184 μg/kg. One soil sample (number IRP15S5-6P) was found to contain ethylbenzene at a concentration of 811 μg/kg (about six times the method detection limit), and three of the ten soil samples contained xylenes at a concentration above 1,000 μg/kg. However, all BTEX concentrations that were detected in site soils are well below petroleum action levels for the State of Ohio (OEPA, 2002). No trichloroethylene was detected above method detection limits in any of the soil samples obtained from the SANGB POL area. Two PAHs, naphthalene and 2-methylnaphthalene, were detected at concentrations ranging from 350 μg/kg to 3,840 μg/kg, and <660 μg/kg to 2,000 μg/kg, respectively.

Table 4-1: Analytical Data Summary, SANGB POL Area
TPHCWG Demonstration Project[1]

Field Sample Numbers →	B01S4-5P	B02S5-6P	B03S5-6P	B04S5-6P	B08S5-6P	B09S5-6P	B10S5-6P[2]	B12S5-6P	B14S5-6P	B15S5-6P	B16S5-6BK[3]
Depth (feet bgs)	4.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
PID reading (highest in ppm)	30	140	374	216	1287	409	478	419	356	336	0
Moisture (% by weight)	9.02	10.20	9.07	10.50	8.96	9.51	9.94	12.00	11.20	10.40	10.80
VOCs (ug/kg)											
benzene	<113	<111	<126	<137	<136	<125	<125	<120	<137	<123	<127
toluene	<113	<111	183	<137	<136	163	179	<120	<137	184	<127
ethylbenzene	138	<111	<126	171	<136	<125	<125	<120	<137	811	<127
xylene	<113	<111	434	<137	1080	410	1090	1588	<137	143	<127
trichloroethylene	<690	<700	<690	<700	<690	<690	<690	<710	<700	<700	<700
PAHs (ug/kg)											
acenaphthene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
pyrene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
naphthalene	350	1010	3840	1290	2420	2260	2370	1470	<1000	1990	<1000
acenaphthylene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
fluorene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
phenanthrene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
anthracene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
fluoranthene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
benzo(a)anthracene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
chrysene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
benzo(b)fluoranthene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
benzo(k)fluoranthene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
benzo(a)pyrene	<660	<670	<660	<670	<660	<660	<670	<680	<680	<670	<670
indeno(1,2,3-cd)pyrene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
dibenz(a,h)anthracene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
benzo(g,h,i)perylene	<550	<560	<550	<560	<550	<550	<560	<570	<560	<560	<560
2-methylnaphthalene	<660	<670	2000	<670	1300	1800	810	<680	<680	1100	<670
TPH-GRO (mg/kg)	9.1	58	180	25	270	120	200	220	73	120	<1.1
TPH-DRO (mg/kg)	22	53	270	34	230	230	360	150	150	73	<13
Total TPH (GRO+DRO) (mg/kg)	31.1	111	450	59	500	350	560	370	223	193	<13
Total TPH Fractions (mg/kg)[4]	32	127	560	<22	312	366	271	310	147	89	<22
HYDROCARBON FRACTIONS (Dry Weight Data) (mg/kg)											
Aliphatics - TPHCWG Method											
Volatile Range 1[5]	0.25	<2.2	<4.4	<2.2	<8.8	<2.2	<8.90	<4.5	<2.3	4.6	0.25
Volatile Range 2[6]	2.6	6.6	<4.4	8.4	45	22	23	33	25	50	<0.22
EC>8-10	<22	38	100	<22	98	60	55	100	<23	<22	<22
EC>10-12	<22	30	140	<22	89	93	83	94	32	<22	<22
EC>12-16	<22	<22	170	<22	57	130	76	60	55	32	<22
EC>16-21	<22	<22	<22	<22	<22	<22	<22	<23	<23	<22	<22
EC>21-35	<22	<22	<22	<22	<22	<22	<22	<23	<23	<22	<22
Aromatics - TPHCWG Method											
Volatile Range 1[5]	<0.0055	<0.056	<0.11	<0.056	<0.22	<0.055	<0.22	<0.11	0.059	0.093	<0.0056
Volatile Range 2[6]	0.023	<0.056	<0.11	<0.056	<0.22	<0.055	0.26	<0.11	<0.056	0.056	<0.0056
EC>8-10	<22	<22	<22	<22	<22	<22	<22	<23	<23	<22	<22
EC>10-12	<22	<22	47	<22	22	24	<22	<23	<23	<22	<22
EC>12-16	<22	<22	69	<22	<22	39	23	<23	<23	<22	<22
EC>16-21	<22	<22	<22	<22	<22	<22	<22	<23	<23	<22	<22
EC>21-35	<22	<22	<22	<22	<22	<22	<22	<23	<23	<22	<22
Total TPH Fractions (mg/kg)[4]	32	127	560	<22	312	366	271	310	147	89	<22
Aliphatics - MA DEP Method											
C5-8 (VPH)	8.7	26.9	116	21.5	142	66.7	132	94.3	70.8	114	
C9-12 (VPH)	25.9	88.8	209	31.3	330	166	380	282	101	89	
C9-18 (EPH)	6.4	16	93	19	100	210	140	70	46	59	
C19-36 (EPH)[7]											
Aromatics - MA DEP Method											
C9-10 (VPH)	11.7	38	112	23	134	96.9	166	123	60.1	67	
C11-22 (EPH)[7]			19		17	35					
Total TPH Fractions (mg/kg)	52.7	169.7	549	94.8	723	574.6	818	569.3	277.9	329.7	<6.35

[1] Nondetects (<###) varied from sample to sample due to moisture content; [2] Duplicate soil sample; [3] Background soil sample;

[4] Total TPH fraction concentrations include values set to 1/2 the detection limit for nondetects (<###);

[5] EC5-6 aliphatic (total) hydrocarbons; EC>6-7 aromatic hydrocarbons (benzene only); VPH = volatile petroleum hydrocarbons

[6] EC>6-8 aliphatic (total minus benzene and toluene) hydrocarbons; EC>7-8 aromatics (toluene only); EPH = extractable petroleum hydrocarbons

[7] Blank = fraction not detected

4.3 TPH GRO and TPH DRO

TPH GRO and TPH DRO were detected in all nine of the primary soil samples collected for this demonstration. TPH GRO concentrations ranged from 9.1 mg/kg to 270 mg/kg. TPH DRO concentrations ranged from 22 mg/kg to 360 mg/kg. The highest concentration of TPH (GRO + DRO) was 560 mg/kg, detected in soil sample number IRPB10S5-6P. Only two of the primary samples (numbers IRP4B01S4-5P and IRP4B04S5-6P) contained TPH (GRO + DRO) at a concentration that precluded an analysis of TPH aliphatic and TPH aromatic fractions by the direct method. Consequently, seven of the nine primary soil samples collected for this demonstration were found to contain sufficient TPH (GRO + DRO) to support TPH aliphatic and TPH aromatic fractional analysis by the direct method.

4.4 TPH Aliphatic and TPH Aromatic Fractions

As shown in Table 4-1, most of the TPHs detected in SANGB POL area soils were aliphatic hydrocarbons in the EC>8-10 and EC>10-12 ranges. Very low concentrations of light aliphatic hydrocarbons and only trace concentrations of light aromatic hydrocarbons were detected. This result, in combination with the finding of very low concentrations of BTEX, indicates that the TPH detected in site soils is composed of a weathered petroleum mixture.

4.5 MA DEP Aliphatic and MA DEP Aromatic Fractions

The aliphatic and aromatic fractions detected in site soils using the MA DEP analytical methodology also indicate that the TPH in SANGB POL area soils is predominately composed of aliphatic hydrocarbons in the C9-12 fraction. No aliphatic hydrocarbons were detected in the C19-36 fraction and only a few samples were found to contain any aromatic hydrocarbons in the C11-22 fraction. However, it is important to note that more than a one-to-one soil to methanol volume ratio was inserted in the laboratory-prepared glass vials used during field sampling activities. The excess soil made these vials unusable for MA DEP VPH analysis. Consequently, the analytical laboratory used the larger soil composite samples to obtain the 15 g of headspace soil that was added to 15 mL of methanol to perform the MA DEP VPH analysis.

4.6 Field Sampling and Laboratory Quality Control

Field quality assurance/quality control (QA/QC) measures included two rinsate blanks, a deionized water blank, and a laboratory-prepared trip blank that accompanied the sample bottles from the laboratory to the field and from the field to the laboratory. These water samples were analyzed for BTEX. No BTEX was detected above method detection limits in any of these field QA/QC samples.

Laboratory QA/QC measures included the collection and submission of one "blind" field duplicate sample (sample number IRP4B10S5-6P) and a sample collected from a "background" sampling location (sample number IRP4B16S5-6P). Although the analytical results between sample number IRP4B08S5-6P and its duplicate are somewhat different, the difference is most likely the result of sample collection techniques. Because the primary sample contained insufficient soil to prepare a sample duplicate, a second sample core was obtained as close to the primary core location as possible. Consequently, the primary sample and the sample duplicate would be expected to show some differences in hydrocarbon concentrations.

However, the analytical results between the two samples are sufficiently comparable to indicate good laboratory techniques were employed.

Internal laboratory QA/QC measures included the preparation and analysis of laboratory control samples, including a matrix spike sample, and laboratory control sample duplicates, including a matrix spike duplicate sample, to assess the degree to which analytical data met limits of quantitation and relative percent difference goals specified for each method. Poor surrogate recoveries were observed for some soil samples indicating a significant matrix effect. Poor surrogate recoveries for a few soil samples were also attributable to the dilution needed to perform the analysis. However, agreement was obtained between the primary and duplicate soil samples. Overall, the analytical results were found to be acceptable by the Laboratory's QA/QC measures.

4.7 Comparison of TPHCWG and MA DEP Fractional Analysis Data

Although the MA DEP fractional analysis results are consistent with the TPHCWG fractional analysis data, it is evident that the MA DEP methodology tends to overestimate the concentrations of TPH (aliphatic and aromatic fractions) in site soils. Some of the overestimation can be attributed to "double addition" that results from the overlap between the C9-12 (VPH) aliphatic fraction and the C9-18 (EPH) aliphatic fraction. When the fractional analysis results obtained using the TPHCWG methodology are compared to the TPH (GRO + DRO) results, the Direct Method appears to underestimate the concentrations of TPH in soil at this site. Underestimation is largely due to the matrix effects seen in the spiked QA/QC samples. The overestimation of TPH using the MA DEP methodology and the underestimation of TPH using the Working Group methodology is particularly evident in sample number IRP4B08S5-6P (and its duplicate IRP4B10S5-6P). However, a detailed analysis of the data by the analytical laboratory was unable to determine if the apparent disparity for these two samples was due to sample-to-sample variability or some systematic bias in the analyses. Although some light aliphatic and aromatic hydrocarbons may have been lost in the MA DEP VPH analyses (as a result of the sample collection problem noted above), the good consistency between the TPHCWG and MA DEP analytical data, particularly in the lighter aromatic and aliphatic fractions, indicates that any losses in the MA DEP VPH analyses were small.

Analytical costs for the Direct Method, on a per sample basis, are somewhat higher than the analytical costs for the MA DEP method. The MA DEP analyses (VPH and EPH) together quantify six fractions while the Direct Method provides analytical data for a total of 14 fractions. The charge for the MA DEP analyses is about two-thirds the cost of performing the entire Direct Method. The extra fractional analyses result in a higher cost but a better range of data.

4.8 Comparison of Field Screening Results with Analytical Data

Field screening data obtained with a portable PID are shown in Table 4-1. The PID readings were taken immediately above the soil cores and reflect the highest value that was obtained at each sampling location. With the exception of the PID readings obtained for sample numbers IRP4B04S5-6P and IRP4B08S5-6P, there was generally good agreement between the field screening results and the total TPH (GRO + DRO) detected in the soil samples collected for this demonstration project. Overall, there was also relatively good agreement between the petroleum odor noted by the sampling team and the PID readings.

4.9 Fingerprint Analysis of TPH Fractions

The analytical data shown in Table 4-1 above were subjected to a first order "fingerprint" analysis as shown in Tables 4-2 through 4-4 below. This first order "fingerprint" analysis contains a summary of the weight fraction of aliphatic and aromatic compounds that were detected in each sample. The TPH fingerprint using the TPHCWG fractions is shown in Table 4-2 and the TPH fingerprint using the MA DEP fractions is shown in Table 4-3. The fingerprint analysis was performed using the five samples that contained the highest concentrations of TPH (GRO + DRO). These five samples were IRP4B03S5-6P, IRP4B08S5-6P (its duplicate, IRP4B10S5-6P), IRP4B09S5-6P and IRP4B12S5-6P. For these five samples, the weight percent of aliphatic fractions ranged from 74.05% to 83.92% using the TPHCWG methodology (see Table 4-2). The weight percent of aliphatic fractions using the MA DEP methodology ranged from 77.8% to 81.3% (see Table 4-3). Similarly, the weight percent of aromatic fractions ranged from 16.08% to 25.95% using the TPHCWG methodology and from 18.7% to 22.2% using the MA DEP methodology.

Further analysis of the TPHCWG and MA DEP fraction fingerprints indicated generally good agreement between the average weight fractions of the heavier aliphatic and aromatic hydrocarbons and the average weight percent of DRO (65.98% vs. 55.3% for the TPHCWG fractions and 63.34% vs. 55.3% for the MA DEP fractions). There was also good agreement between the average weight fractions of the lighter aliphatic and aromatic hydrocarbons and the average weight percent of GRO (33.90% vs. 44.7% for the TPHCWG fractions and 36.6% vs. 44.7% for the MA DEP fractions). The overall consistency between the TPHCWG and MA DEP fraction "fingerprints" indicates that the petroleum contamination in SANGB POL area soils came from a single source (i.e., the jet fuel USTs). This "fingerprint" also indicates that the petroleum hydrocarbon contamination is not the result of a recent release, because it is composed of a weathered petroleum product (i.e., it contains relatively low concentrations of the lighter aliphatic and aromatic fractions and little or no BTEX). A direct comparison of the fingerprint analysis results between the TPHCWG fractions and the MA DEP fractions is shown in Table 4-4.

Table 4-2: TPHCWG Fractions "Fingerprint" Analysis, SANGB POL Area

Sample Numbers →	IRP4B03S5-6P	IRP4B08S5-6P	IRP4B09S5-6P	IRP4B10S5-6P	IRP4B12S5-6P
TPH Fractions	Wt. Frac.	Wt. Frac.	Wt. Frac.	Wt. Frac.	Wt. Frac.
↓	mg/kg/mg/kg	mg/kg/mg/kg	mg/kg/mg/kg	mg/kg/mg/kg	mg/kg/mg/kg
EC5-6 Aliphatics	3.73E-03	1.02E-02	2.46E-03	1.24E-02	5.56E-03
EC>6-8 Aliphatics	3.73E-03	1.04E-01	4.92E-02	6.43E-02	8.15E-02
EC>8-10 Aliphatics	1.70E-01	2.27E-01	1.34E-01	1.54E-01	2.47E-01
EC>10-12 Aliphatics	2.37E-01	2.07E-01	2.08E-01	2.32E-01	2.32E-01
EC>12-16 Aliphatics	2.88E-01	1.32E-01	2.91E-01	2.12E-01	1.48E-01
EC>16-21 Aliphatics	1.87E-02	2.55E-02	2.46E-02	3.07E-02	2.84E-02
EC5-7 Aromatics	9.33E-05	2.55E-04	6.26E-05	3.07E-04	1.48E-04
EC>7-8 Aromatics	1.02E-04	2.55E-04	6.71E-05	7.26E-04	1.48E-04
EC>8-10 Aromatics	1.87E-02	2.55E-02	2.46E-02	3.07E-02	2.84E-02
EC>10-12 Aromatics	7.97E-02	5.11E-02	5.37E-02	3.07E-02	2.84E-02
EC>12-16 Aromatics	1.17E-01	2.55E-02	8.72E-02	6.43E-02	2.84E-02
EC>16-21 Aromatics	1.87E-02	2.55E-02	2.46E-02	3.07E-02	2.84E-02
EC>21-35 Aromatics	1.87E-02	2.55E-02	2.46E-02	3.07E-02	2.84E-02
Total[1]	9.74E-01	8.60E-01	9.24E-01	8.94E-01	8.85E-01
Aliphatics	74.05%	82.13%	76.75%	78.94%	83.92%
Aromatics	25.95%	17.87%	23.25%	21.06%	16.08%
EC>10-12 Aliphatics	24.40	24.00	22.50	26.00	26.20
EC>12-16 Aliphatics	29.60	15.40	31.50	23.80	16.70
EC>16-21 Aliphatics	1.91	2.97	2.66	3.44	3.21
EC>10-12 Aromatics	8.18	5.94	5.81	3.44	3.21
EC>12-16 Aromatics	12.01	2.97	9.44	7.19	3.21
EC>16-21 Aromatics	1.91	2.97	2.66	3.44	3.21
% of Total Fractions	78.02	54.24	74.57	67.31	55.74
DRO (% of Total TPH)	60.00	46.00	65.70	64.30	40.50
EC5-6 Aliphatics	0.38	1.19	0.27	1.39	0.63
EC>6-8 Aliphatics	0.38	12.14	5.32	7.19	9.21
EC>8-10 Aliphatics	22.90	27.70	17.48	19.47	29.42
EC5-7 Aromatics	0.01	0.03	0.01	0.03	0.02
EC>7-8 Aromatics	0.01	0.03	0.01	0.08	0.02
EC>8-10 Aromatics	1.91	2.97	2.66	3.44	3.21
% of Total Fractions	25.59	44.06	25.75	31.61	42.50
GRO (% of Total TPH)	40.00	54.00	34.30	35.70	59.50

[1] Total includes weight fractions set to 1/2 detection limit values for non-detects

Table 4-3: MA DEP Fractions "Fingerprint" Analysis, SANGB POL Area

Sample Numbers →	IRP4B03S5-6P	IRP4B08S5-6P	IRP4B09S5-6P	IRP4B10S5-6P	IRP4B12S5-6P
TPH Fractions	Wt. Frac.	Wt. Frac.	Wt. Frac.	Wt. Frac.	Wt. Frac.
↓	mg/kg/mg/kg	mg/kg/mg/kg	mg/kg/mg/kg	mg/kg/mg/kg	mg/kg/mg/kg
C5-8 Aliphatics	2.14E-01	1.97E-01	1.21E-01	1.59E-01	1.62E-01
C9-12 Aliphatics	3.85E-01	4.59E-01	3.00E-01	4.57E-01	4.84E-01
C12-18 Aliphatics	1.71E-01	1.39E-01	3.80E-01	1.68E-01	1.20E-01
C19-36 Aliphatics	1.20E-02	9.04E-03	1.18E-02	7.82E-03	1.12E-02
C9- 10 Aromatics	2.06E-01	1.86E-01	1.75E-01	2.00E-01	2.11E-01
C11-22 Aromatics	1.20E-02	9.04E-03	1.18E-02	7.82E-03	1.12E-02
Total[1]	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Aliphatics	78.2%	80.5%	81.3%	79.2%	77.8%
Aromatics	21.8%	19.5%	18.7%	20.8%	22.2%
C9-C12 Aliphatics	38.5	45.9	30.0	45.7	48.4
C9-C18 Aliphatics	17.1	13.9	38.0	16.8	12.0
C19-C36 Aliphatics	1.2	0.9	1.2	0.8	1.1
>C11-C22 Aromatics	1.2	0.9	1.2	0.8	1.1
% of Total Fractions	58.0	61.6	70.4	64.1	62.6
DRO (% of Total TPH)	60.0	46.0	65.7	64.3	40.5
C5-C8 Aliphatics	21.4	19.7	12.1	15.9	16.2
C9-C10 Aromatics	20.6	18.6	17.5	20.0	21.1
% of Total Fractions	42.0	38.3	29.6	35.9	37.3
GRO (% of Total TPH)	40.0	54.0	34.3	35.7	59.5

[1] Total includes weight fractions set to 1/2 detection limit values for non-detects

Table 4-4: TPHCWG vs. MA DEP Fractions "Fingerprint" Analysis

Sample Numbers →	IRP4B03S5-6P	IRP4B08S5-6P	IRP4B09S5-6P	IRP4B10S5-6P	IRP4B12S5-6P
TPH Fractions	Wt. Frac.	Wt. Frac.	Wt. Frac.	Wt. Frac.	Wt. Frac.
↓	mg/kg/mg/kg	mg/kg/mg/kg	mg/kg/mg/kg	mg/kg/mg/kg	mg/kg/mg/kg
TPHCWG Aliphatics	74.05%	82.13%	76.75%	78.94%	83.92%
TPHCWG Aromatics	25.95%	17.87%	23.25%	21.06%	16.08%
MA DEP Aliphatics	78.20%	80.50%	81.30%	79.20%	77.80%
MA DEP Aromatics	21.80%	19.50%	18.70%	20.80%	22.20%
% TPHCWG "DRO" Fractions	78.0	54.2	74.6	67.3	55.7
% MA DEP "DRO" Fractions	58.0	61.6	70.4	64.1	62.6
DRO (% of Total TPH)	60.0	46.0	65.7	64.3	40.5
% TPHCWG "GRO" Fractions	25.6	44.1	25.8	31.6	42.5
% MA DEP "GRO" Fractions	42.0	38.3	29.6	35.9	37.3
GRO (% of Total TPH)	40.0	54.0	34.3	35.7	59.5

5.0 TIER 1 RBSLs CALCULATED FROM TPH FRACTIONAL ANALYSIS DATA

5.1 RBSLs for Commercial/Industrial Exposure Scenario

Commercial/Industrial Tier 1 RBSLs are presented in Tables A-2 through A-45 located in Appendix A. Among the direct and indirect soil exposure pathways, the subsurface soil indoor vapor inhalation pathway consistently contained the lowest total TPH RBSLs, ranging from 1.2 mg/kg (for the MA DEP C5-8 aliphatic fraction) to 16,000 mg/kg (for the MA DEP C9-18 aliphatic fraction). For this pathway all nine samples exceeded their respective total TPH RBSLs, using the MA DEP fractions, and seven of the ten samples exceeded their respective total TPH RBSLs, using the TPHCWG fractions, as shown in Table 5-1. (Note that boxed values in bold exceed their respective RBSLs.) Much of the risk is attributable to the elevated concentrations of TPH in the EC>8-10, EC>10-12, and EC>12-16 aliphatic fractions. However, it should be noted that the concentrations of TPH in the EC>5-6, EC>6-8, and EC>16-21 aliphatic fractions and in most of the aromatic fractions results from using a value of one-half of the detection limit for those fractions that were not detected above the method detection limit. Clearly, when the RBSL is small, as it is for the subsurface soil indoor inhalation pathway, the concentration of TPH calculated for a given sample may exceed the total TPH RBSL even when no hydrocarbons were detected in most of the fractions.

Because there is only one infrequently occupied building (Building 106) in the immediate vicinity of the petroleum contaminated soils, the subsurface soil indoor vapor inhalation pathway provides an extremely conservative estimate of the actual risk to commercial/industrial receptors. Consequently, additional calculations were made for the subsurface soil outdoor vapor inhalation pathway. For this pathway, the total TPH RBSLs range from 23 mg/kg for the EC5-7 aromatic fraction to 110,000 mg/kg for the EC>12-16 aromatic fraction. None of the samples analyzed for the TPHCWG fractions contained TPH at a concentration that exceeded any of the fraction-specific RBSLs for this pathway. Five of the ten samples analyzed for the MA DEP fractions exceeded the fraction-specific RBSL for the C5-8 aliphatic fraction, as shown in Table 5-2. (Again note that values in bold exceed their respective RBSLs.) However, the MA DEP RfC for this fraction is nearly two orders of magnitude lower than the TPHCWG RfC for the lighter aliphatic fractions.

From this dual pathway analysis, it is evident that much of the risk attributable to the petroleum hydrocarbon contamination detected in SANG POL area soils for the subsurface soil indoor and outdoor vapor inhalation pathways results from at least two major contributing factors. First, assigning one-half of the detection limit concentration to those fractions that were not detected by the laboratory has significantly elevated the total TPH concentrations used in the risk analysis. Secondly, as illustrated by the data shown in Table 4-1, the MA DEP analytical protocol significantly overestimates the concentrations of petroleum hydrocarbons in site soils as compared to GRO + DRO TPH totals. In the absence of these contributing factors, the risk posed by the petroleum hydrocarbon contamination detected in SANG POL area soils would fall within the acceptable range for human exposure under a commercial/industrial exposure scenario.

Table 5-1: RBSLs for SANGB POL Area, Commercial/Industrial Exposure Scenario, Subsurface Soil Indoor Vapor Inhalation Pathway[1]

Sample #	TPHCWG Aliphatics (mg/kg)						TPHCWG Aromatics (mg/kg)							Total TPH	Total TPH RBSL
IRP4 -	EC5-6	EC>6-8	EC>8-10	EC>10-12	EC>12-16	EC>16-21	EC>5-7	EC>7-8	EC>8-10	EC>10-12	EC>12-16	EC>16-21	EC>21-35	(mg/kg)	(mg/kg)
B01S4-5P	0	3	11	11	11	11	0.0	0	11	11	11	11	11	102	163
B02S5-6P	1	7	**38**	30	11	11	0.0	0	11	11	11	11	11	**153**	93
B03S5-6P	2	2	**100**	140	170	11	0.1	0	11	47	69	11	11	**575**	142
B04S5-6P	1	8	11	11	11	11	0.0	0	11	11	11	11	11	109	144
B08S5-6P	4	45	**98**	89	57	11	0.1	0	11	22	11	11	11	**371**	86
B09S5-6P	1	22	**60**	93	130	11	0.0	0	11	24	39	11	11	**413**	159
B10S5-6P[2]	4	23	**55**	83	76	11	0.1	0	11	11	23	11	11	**320**	116
B12S5-6P	2	33	**100**	94	60	12	0.1	0	12	12	12	12	12	**358**	88
B14S5-6P	1	25	12	32	55	12	0.0	0	12	12	12	12	12	194	196
B15S5-6P	5	50	11	11	32	11	0.1	0	11	11	11	11	12	**175**	136
B16S5-6P[3]	0	0	11	11	11	11	0.0	0	11	11	11	11	12	100	163
RBSL	61	150	34	180	810	No RfC	0.4	34	56	300	1600	No RfC	No RfC		

Sample #	MA DEP Aliphatics (mg/kg)			MA DEP Aromatics (mg/kg)		
IRP4 -	C5-8	C9-18	C19-36	C9-22		
B01S4-5P	**8.7**	32	7	12	**59**	8.2
B02S5-6P	**26.9**	105	7	38	**176**	7.9
B03S5-6P	**116.0**	302	7	131	**556**	5.8
B04S5-6P	**21.5**	50	7	23	**101**	5.7
B08S5-6P	**142.0**	430	7	151	**730**	6.2
B09S5-6P	**66.7**	376	7	132	**581**	10.4
B10S5-6P[2]	**132.0**	520	7	166	**825**	7.5
B12S5-6P	**94.3**	352	7	123	**576**	7.3
B14S5-6P	**70.8**	147	7	60	**284**	4.8
B15S5-6P	**114.0**	148	7	67	**336**	3.5
B16S5-6P[3]	**3.0**	5	7	7	**21**	7.3
RBSL	1.2	16000	No RfC	1200		

[1] Boxed values in bold exceed their respective RBSLs
[2] Duplicate soil sample
[3] Background soil sample

Table 5-2: RBSLs for SANGB POL Area, Commercial/Industrial Exposure Scenario, Subsurface Soil Outdoor Vapor Inhalation Pathway[1]

Sample #	TPHCWG Aliphatics (mg/kg)						TPHCWG Aromatics (mg/kg)							Total TPH	Total TPH RBSL
IRP4 -	EC5-6	EC>6-8	EC>8-10	EC>10-12	EC>12-16	EC>16-21	EC>5-7	EC>7-8	EC>8-10	EC>10-12	EC>12-16	EC>16-21	EC>21-35	(mg/kg)	(mg/kg)
B01S4-5P	0	3	11	11	11	11	0	0	11	11	11	11	11	102	393000
B02S5-6P	1	7	38	30	11	11	0	0	11	11	11	11	11	153	393000
B03S5-6P	2	2	100	140	170	11	0	0	11	47	69	11	11	575	393000
B04S5-6P	1	8	11	11	11	11	0	0	11	11	11	11	11	109	393000
B08S5-6P	4	45	98	89	57	11	0	0	11	22	11	11	11	371	393000
B09S5-6P	1	22	60	93	130	11	0	0	11	24	39	11	11	413	393000
B10S5-6P[2]	4	23	55	83	76	11	0	0	11	11	23	11	11	320	393000
B12S5-6P	2	33	100	94	60	12	0	0	12	12	12	12	12	358	393000
B14S5-6P	1	25	12	32	55	12	0	0	12	12	12	12	12	194	393000
B15S5-6P	5	50	11	11	32	11	0	0	11	11	11	11	12	175	393000
B16S5-6P[3]	0	0	11	11	11	11	0	0	111	11	11	11	12	200	393000
RBSL	4100	9800	2300	12000	54000	No RfC	23	2300	3700	20000	110000	No RfC	No RfC		

Sample #	MA DEP Aliphatics (mg/kg)			MA DEP Aromatics (mg/kg)		
IRP4 -	C5-8	C9-18	C19-36	C9-22		
B01S4-5P	9	32	7	12	59	21600
B02S5-6P	27	105	7	38	176	21600
B03S5-6P	**116**	302	7	131	556	21600
B04S5-6P	22	50	7	23	101	21600
B08S5-6P	**142**	430	7	151	730	21600
B09S5-6P	67	376	7	132	581	21600
B10S5-6P[2]	**132**	520	7	166	825	21600
B12S5-6P	**94**	352	7	123	576	21600
B14S5-6P	71	147	7	60	284	21600
B15S5-6P	**114**	148	7	67	336	21600
B16S5-6P[3]	3	5	7	7	21	21600
RBSL	81	16000	No RfC	78000		

[1] Boxed values in bold exceed their respective RBSLs
[2] Duplicate soil sample
[3] Background soil sample

5.2 State of Ohio Cleanup Standards for Hydrocarbon Contaminated Soil

The Ohio Environmental Protection Agency (OEPA) offers guidance adapted from the Bureau of Underground Storage Tank Regulations (BUSTR) Corrective Actions Guidance Document for situations where a release of petroleum has occurred from a non-BUSTR regulated source (OEPA, 2002). The guidance was developed specifically for emergency response actions. It may not be appropriate for use at sites where long term clean up is necessary, such as where there is extensive groundwater contamination or more than just petroleum contamination.

The guidance provides the "Site Feature Work Sheet" for determining petroleum cleanup standards for non-BUSTR sites. On this work sheet, points are assigned based on the description of each site feature. Once the points have been assigned, the total is matched with the corresponding category in the "Petroleum Action Levels Table" contained in the guidance document. The soil cleanup level for non-gasoline petroleum products (e.g., jet fuel) ranges from 380 mg/kg for Category 1 sites (sites with greater potential for human or ecological exposure) to 1,156 mg/kg for Category 4 sites. Although calculating a score for the SANGB POL area is beyond the scope of this project, only three of the samples collected for this demonstration contained TPH (GRO + DRO) at a concentration above Category 1 cleanup

levels (the most stringent category). The applicable OEPA petroleum action levels are provided in Table 5-3 below (OEPA, 2002).

Table 5-3: OEPA Petroleum Action Levels*

Constituent	Category 1	Category 2	Category 3	Category 4
Total Score	<45 points	46-60 points	61-75 points	>75 points
Soil BTEX	0.006 ppm Benzene 4 ppm Toluene 6 ppm Ethylbenzene 28 ppm Total Xylenes	0.17 ppm Benzene 7 ppm Toluene 10 ppm Ethylbenzene 47 ppm Total Xylenes	0.335 ppm Benzene 9 ppm Toluene 14 ppm Ethylbenzene 67 ppm Total Xylenes	0.5 ppm Benzene 12 ppm Toluene 18 ppm Ethylbenzene 85 ppm Total Xylenes
Groundwater BTEX	0.005 ppm Benzene 1 ppm Toluene 0.7 ppm Ethylbenzene 10 ppm Total Xylenes	0.005 ppm Benzene 1 ppm Toluene 0.7 ppm Ethylbenzene 10 ppm Total Xylenes	0.005 ppm Benzene 1 ppm Toluene 0.7 ppm Ethylbenzene 10 ppm Total Xylenes	0.005 ppm Benzene 1 ppm Toluene 0.7 ppm Ethylbenzene 10 ppm Total Xylenes
Soil TPH (gasoline)	105 ppm TPH	300 ppm TPH	450 ppm TPH	600 ppm TPH
Soil TPH (others)	380 ppm TPH	642 ppm TPH	904 ppm TPH	1156 ppm TPH

* OEPA, 2002

6.0 CONCLUSIONS AND RECOMMENDATIONS

Soil samples were collected at the SANGB POL area for fractional TPH analysis to compare the TPHCWG direct method and the MA DEP analyses. Samples were located on a grid in an area know to have contained TPH contamination from previous studies (SAIC, 1991, 1995; Montgomery Watson, 1999; NETI, 2002).

Eight of the ten soil samples collected within the SANGB POL area for this demonstration project contained TPH at concentrations above the minimum threshold (approximately 100 mg/kg) required to support fractional analysis by the direct method. Most of the TPH that was detected consisted of aliphatic hydrocarbons in the EC>8–10 and EC>10–12 fractions. Very low concentrations of light aliphatic and aromatic hydrocarbons were detected. None of the soil samples were found to contain benzene at a concentration above method detection limits, and only trace concentrations of toluene, ethylbenzene and xylenes were detected. This result, in combination with the finding of very low concentrations of light aliphatic and aromatic fractions, indicates that the TPH detected in site soils is composed of a weathered petroleum mixture. This finding is consistent with the site's history and with previous site investigation data.

The volatile component analysis performed on site soil samples also involved a wide range of organic solvents, including trichloroethylene, a commonly used degreasing agent detected during previous investigations of the area. No trichloroethylene or volatile organic compound tested was detected in site soils above their respective method detection limits.

As indicated by the analytical summary data shown in Table 4-1, the TPHCWG fractional analysis results tended to underestimate the total TPH (GRO + DRO) detected in site soils. The MA DEP fractional analysis results, on the other hand, tended to overestimate the total TPH. The underestimation of TPH using the Working Group methodology and the overestimation of TPH using the MA DEP methodology was particularly evident in sample number IRP4B08S5-6P and its duplicate, IRP4B10S5-6P. Most of the overestimation by the MA DEP methodology is probably attributable to "double addition" that results from the overlap between the C9-12 (VPH) aliphatic fraction and the C9-18 (EPH) aliphatic fraction. Most of the underestimation by the TPHCWG methodology is probably the result of poor recoveries of petroleum hydrocarbons from the soil matrix as shown by the low recovery of standards in spiked samples.

Field screening data obtained with a portable PID generally provided a good indication of the presence or absence of petroleum hydrocarbons in the soil cores extracted from the SANGB POL area for this demonstration project. Using this technique, 6 of 14 soil boring locations (excluding the duplicate boring) were rejected, and 7 of the 9 primary soil boring locations that were accepted contained sufficient concentrations of TPH to support the project objectives in Section 1.1.

A first order "fingerprint" analysis of the TPHCWG fractional analysis data and the MA DEP fractional analysis data provided very similar results. Both "fingerprints" indicate that the petroleum hydrocarbon contamination detected in SANG POL area soils contains aliphatic and aromatic fractions in a ratio (by weight percent) of about 4 to 1 and that its composition is approximately 60% DRO and 40% GRO. These "fingerprints" also indicate that the petroleum contamination in SANGB POL area soils came from a single source (i.e., the jet fuel USTs) and that it is not the result of a recent release.

Among the direct and indirect soil exposure pathways, the subsurface soil indoor vapor inhalation pathway consistently contained the lowest total TPH RBSLs. For this pathway, all nine primary samples exceeded their respective total TPH RBSLs using the MA DEP fractions and seven of the ten samples exceeded their respective total TPH RBSLs using the TPHCWG fractions. Because there is only one infrequently occupied building (Building 106) in the immediate vicinity of the petroleum contaminated soils, the subsurface soil indoor vapor inhalation pathway provides an extremely conservative estimate of the actual risk to commercial/industrial receptors.

An additional risk assessment was performed for the subsurface soil outdoor vapor inhalation pathway. None of the samples analyzed for the TPHCWG fractions contained TPH at a concentration that exceeded any of the fraction-specific RBSLs. However, five of the ten samples analyzed for the MA DEP fractions exceeded the fraction-specific RBSL for the C5-8 aliphatic fraction. This significant difference in risk was expected because the MA DEP RfC for this fraction is nearly two orders of magnitude lower than the TPHCWG RfC (0.2 mg/m^3 vs. 18.4 mg/m^3).

Although the Tier 1 risk results obtained for the SANGB POL area indicate a need for some form of corrective action, there are several important mitigating factors that must be considered. First, the highest risk for exposure to commercial/industrial receptors at the site is

through the subsurface soil indoor vapor inhalation pathway. The Tier 1 RBSLs for this pathway are calculated using the following assumptions: (1) a constant chemical concentration in subsurface soils; (2) linear equilibrium partitioning within the soil matrix between sorbed, dissolved and vapor phases, where the partitioning is a function of constant chemical- and soil-specific parameters; (3) steady-state vapor- and liquid-phase diffusion through the vadose zone and foundation cracks; (4) no loss of chemicals as they diffuse towards the ground surface (i.e., no attenuation/biodegradation); (5) well-mixed atmospheric dispersion of the emanating vapors within the enclosed space (i.e., within Building 106); and (6) one percent of the foundation area is cracked through the total foundation thickness. Second, the concentrations of TPH have been inflated by using a value of one-half of the detection limit for those fractions that were not detected by the laboratory. Third, the concentrations of TPH in the lighter aliphatic fractions are significantly overestimated by the MA DEP methodology. Because of these mitigating factors, the actual risk posed to commercial/industrial receptors within the SANGB POL area is probably well within the acceptable risk range. However, a higher tier risk assessment (i.e., Tier 2) using site-specific fate and transport data would be needed to reveal the degree of conservatism in the Tier 1 findings. The cost of performing a higher tier risk assessment should be weighed against the cost of any remedial measures that may be considered.

Overall, the results obtained using the TPHCWG methodology and the MA DEP methodology in this demonstration project are reasonably comparable. Total TPH concentrations across the TPHCWG and MA DEP fractions compare reasonably well with the total TPH (GRO + DRO). Both approaches provide data that give essentially the same TPH "fingerprint". Both approaches also provide fractional analysis data that can be used within the RBCA framework to assess the risk posed to potential human receptors by petroleum hydrocarbon contamination in site soils. However, the TPHCWG approach is more robust than the MA DEP methodology because it provides better insight into the nature of petroleum hydrocarbon contamination (i.e., more fractional analysis data) and is less likely to overestimate the risk posed to human receptors under the same exposure scenario.

7.0 REFERENCES

American Society for Testing and Materials (ASTM). 1995. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites, E 1739 – 95. ASTM, West Conshohocken, PA.

Gustafson, J.B., Griffith-Tell, J., Orem, D. 1997. Total Petroleum Hydrocarbon Criteria Working Group Series, Volume 3: Selection of Representative TPH Fractions Based on Fate and Transport Considerations. Amherst Scientific Publishers, Amherst, MA. 137 p.

Massachusetts Department of Environmental Protection (MA DEP). 1998a. Method for the Determination of Volatile Petroleum Hydrocarbons (VPH). MA DEP Bureau of Waste Site Cleanup, Boston, MA.

Massachusetts Department of Environmental Protection (MA DEP). 1998b. Method for the Determination of Extractable Petroleum Hydrocarbons (EPH). MA DEP Bureau of Waste Site Cleanup, Boston, MA.

Massachusetts Department of Environmental Protection (MA DEP). 2002. Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of the MA DEP VPH/EPH Approach, Final Policy #WSC-02-411. MA DEP Bureau of Waste Site Cleanup, Boston, MA.

Montgomery Watson. 1999. Final Remedial Investigation Report, Volume I, 178th Fighter Wing, Ohio Air National Guard Base, Springfield, Ohio. Novi, MI.

Native Energy and Technology, Inc. (NETI). 2002. Draft Site Assessment Report for

Building 106 Gravel Area, 178th Fighter Wing, Ohio Air National Guard, Springfield Air National Guard Base, Springfield-Beckley Municipal Airport, Springfield, Ohio. San Antonio, TX.

Ohio Environmental Protection Agency (OEPA). Jan 2002. Petroleum Contaminated Sites Guidance Document for Emergency Response Actions. OEPA, Division of Emergency and Remedial Response, Columbus, OH.

Perry, R.H., Chilton, C.H., eds. 1973. Chemical Engineer's Handbook, 5th Edition. McGraw-Hill Publishing Co., New York. pp. 4-64, 4-65.

Reed, D.A. 2002. Site-Specific Work Plan [Draft]: Total Petroleum Hydrocarbon Criteria Working Group Demonstration, POL Storage Area, Springfield Air National Guard Base, Springfield, Ohio. OpTech, Beavercreek, OH.

Science Applications International Corp. (SAIC). 1991. Installation Restoration Program Report, Ohio Air National Guard, Springfield-Beckley Municipal Airport, Springfield, Ohio and Blue Ash National Guard Station, Cincinnati, Ohio, Quality Assurance Project Plan, Draft Final. McLean, VA.

Science Applications International Corp. (SAIC). 1995. Final Site Investigation Report, Ohio Air National Guard, 178th Fighter Group, Springfield-Beckley Municipal Airport, Springfield, Ohio. McLean, VA.

Vorhees, D., Gustafson, J, Weisman, W. 1999. Total Petroleum Hydrocarbon Criteria Working Group Series, Volume 5: Human Health Risk-Based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach. Amherst Scientific Publishers, Amherst, MA, 98 p.

Washington State Department of Ecology (WDE). 1997. Analytical Methods for Petroleum Hydrocarbons.

Weisman, W. (ed.). 1998. Total Petroleum Hydrocarbon Criteria Working Group Series, Volume 1: Analysis of Petroleum Hydrocarbons in Environmental Media. Amherst Scientific Publishers, Amherst, MA, 98 p.

APPENDIX A:

TPH FRACTION RBSLs AND ASSOCIATED COMPOSITION DATA FOR COMMERCIAL/INDUSTRIAL EXPOSURE SCENARIO

TPHCWG Demonstration
IRP Site 4, POL Area
Springfield ANG Base
Springfield, Ohio

Table A-1: Exposure Assumptions

Exposure Parameters for

	Pathways:	Inhalation	Dermal Contact	etc...		
	Scenario:	Future	Current			
	Exposed Population:	Commercial	Commercial Receptor			
Variable		Subchronic Hazard Index Calculations [S = Subchronic	Chronic Hazard Index Calculations C = Chronic	Excess Lifetime Cancer Risk Calculations CA = Cancer]	Units	Notes & References
GENERAL INFO:						
Age		6 to 30	6 to 30	6 to 30	years	
Bodyweight		70	70	70	kg	
INGESTION OF SOIL (IS):						
Ingestion Rate (IR)			50		mg soil/day	
Conversion Factor (CF)			1.00E-06		kg/mg	
Fraction Ingested (FI)			1		unitless	
Exposure Frequency (EF)			250		days/year	
Exposure Duration (ED)			25		years	
Averaging Time (AT)			25		years	
DERMAL CONTACT WITH SOIL/SEDIMENT (DC):						
Conversion Factor (CF)			1.00E-06		kg/mg	
Skin Surface Area (SA)			3160		cm^2/day	Assumes 1 day
Head						
Trunk						
Upper Extremities						
Arms						
Upper Arms						
Forearms						
Hands						
Lower Extremities						
Legs						
Thighs						
Lower Legs						
Feet						
Soil Adherence Factor (SAF)			0.5		mg/cm^2	
Head						
Trunk						
Upper Extremities						
Arms						
Upper Arms						
Forearms						
Hands						
Lower Extremities						
Legs						
Thighs						
Lower Legs						
Feet						
Absorption Factor (AF)					unitless	Note: Absorption is incorporated in RBSL calculation
Exposure Frequency (EF)			250		days/year	on the exposure assumptions page
Exposure Duration (ED)			25		years	
Averaging Time (AT)			25		years	

INHALATION OF PARTICULATES/VAPORS (I):

Inhalation rate (outdoor) (INR)	20		m^3/day
Exposure Frequency (EF)	250		days/year
Exposure Duration (ED)	25		years
Averaging Time (AT)	25		years

INHALATION OF VAPORS (Indoor Air) (IA)

Inhalation rate (indoor) (IHR)	20		m^3/day
Exposure Frequency (EF)	250		days/year
Exposure Duration (ED)	25		years
Averaging Time (AT)	25		years

INGESTION OF DRINKING WATER OR GROUNDWATER (DW)

Ingestion Rate (IR)	1		liters/day
Exposure Frequency (EF)	250		days/year
Exposure Duration (ED)	25		years
Averaging Time (AT)	25		years

Table A-2: TPH Composition Data using TPHCWG Direct Method for Sample IRP4B01S4-5P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): IRP4B01S4-5P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.113	0.0565	5.55E-02	7.11E-04	1.15E-01
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.55	0.275	2.70E-01	1.18E-03	1.91E-01
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.66	0.33	3.24E-01	1.29E-03	2.07E-01
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.55	0.275	2.70E-01	1.07E-03	1.73E-01
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.55	0.275	2.70E-01	1.07E-03	1.73E-01
218-01-9	Chrysene	2.28E+02	<	0.55	0.275	2.70E-01	1.18E-03	1.91E-01
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.55	0.275	2.70E-01	9.71E-04	1.57E-01
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.55	0.275	2.70E-01	9.78E-04	1.58E-01
	TPH fractions							
	C>5-C6 aliphatics	8.10E+01		0.25	0.25	2.45E-01	3.03E-03	4.88E-01
	C>6-C8 aliphatics	1.00E+02		2.6	2.6	255E+00	2.55E-02	4.12E+00
	C>8-C10 aliphatics	1.30E+02	<	22	11	1.08E+01	8.31E-02	1.34E+01
	C>10-C12 aliphatics	1.60E+02	<	22	11	1.08E+01	6.75E-02	1.09E+01
	C>12-C16 aliphatics	2.00E+02	<	22	11	1.08E+01	5.40E-02	8.70E+00
	C >16-C21aliphatics	2.70E+02	<	22	11	1.08E+01	4.00E-02	6.45E+00
	C>5-C7 aromatics	7.80E+01	<	0.0055	0.00275	2.70E-03	3.46E-05	5.58E-03
	C>7-C8 aromatics	9.21E+01		0.023	0.023	2.26E-02	2.45E-04	3.95E-02
	C >8 - C10 aromatics	1.20E+02	<	22	11	1.08E+01	9.00E-02	1.45E+01
	C>10-C12 aromatics	1.30E+02	<	22	11	1.08E+01	8.31E-02	1.34E+01
	C>12-C16 aromatics	1.50E+02	<	22	11	1.08E+01	7.20E-02	1.16E+01
	C>16-C21 aromatics	1.90E+02	<	22	11	1.08E+01	5.68E-02	9.16E+00
	C>21-C35 aromatics	2.40E+02	<	22	11	1.08E+01	4.50E-02	7.25E+00

Total TPH fractions		*Sum of weight %*	6.20E-01
aliphatics	46.85	100	
aromatics	55.02575		
Total	101.87575		

Table A-3: TPH Fraction RBSLs using TPHCWG Direct Method for Sample IRP4B01S4-5P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
>5-6 Aliphatics	4.7E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	4.1E+03	6.1E+01	8.1E+04	1.0E+04	1.4E+01	5.1E+02
>6-8 Aliphatics	2.6E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	9.8E+03	1.5E+02	2.9E+05	6.8E+03	9.3E+00	5.1E+02
>8-10 Aliphatics	1.4E+02	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	2.3E+03	3.4E+01	4.1E+04	2.3E+02	3.2E-01	1.0E+01
>10-12 Aliphatics	8.6E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	1.2E+04	1.8E+02	3.1E+05	1.5E+02	2.1E-01	1.0E+01
>12-16 Aliphatics	3.8E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	5.4E+04	8.1E+02	6.2E+06	3.6E+01	4.9E-02	1.0E+01
>16-21 Aliphatics	1.6E+01	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	1.6E+10	No RfC	No RfC	2.0E+02
>5-7 Aromatics	1.6E+03	2.0E+03	1.3E+02	5.7E+09	2.2E+03	1.2E+02	2.2E+03	2.3E+01	3.5E-01	1.1E+00	5.2E+02	8.4E-01	1.0E-01
>7-8 Aromatics	1.3E+03	4.1E+05	2.6E+04	2.5E+11	9.7E+04	1.9E+04	9.7E+04	2.3E+03	3.4E+01	6.1E+02	2.1E+04	3.3E+01	2.0E+01
>8-10 Aromatics	1.0E+03	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	3.7E+03	5.6E+01	7.9E+02	6.1E+03	8.9E+00	4.1E+00
>10-12 Aromatics	6.3E+02	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	2.0E+04	3.0E+02	1.2E+03	1.4E+04	2.4E+01	4.1E+00
>12-16 Aromatics	2.9E+02	8.2E+04	5.2E+03	1.3E+11	6.4E+04	4.5E+03	6.4E+04	1.1E+05	1.6E+03	2.5E+03	2.3E+04	5.1E+01	4.1E+00
>16-21 Aromatics	1.0E+02	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	5.9E+03	No RfC	No RfC	3.1E+00
>21-35 Aromatics	8.3E+00	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	4.7E+04	No RfC	No RfC	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
>5-6 Aliphatics	2.5E-03	2.6E-05	2.6E-05	6.8E-05	5.1E-07	2.9E-05	5.1E-07	5.6E-04	6.5E-03	2.8E-05	1.7E-05	1.3E-02	7.3E-05
>6-8 Aliphatics	2.6E-02	2.7E-04	2.7E-04	7.1E-04	2.4E-06	3.0E-04	2.4E-06	1.1E-03	2.8E-02	3.6E-05	3.3E-05	2.4E-02	4.3E-04
>8-10 Aliphatics	1.1E-01	5.8E-02	5.8E-02	5.5E-02	7.8E-05	5.8E-02	7.8E-05	8.2E-03	5.1E-01	4.7E-04	2.5E-04	1.8E-01	5.6E-03
>10-12 Aliphatics	1.1E-01	5.8E-02	5.8E-02	5.5E-02	3.8E-05	5.8E-02	3.8E-05	7.9E-04	5.3E-02	3.0E-05	2.4E-05	1.8E-02	3.6E-04
>12-16 Aliphatics	1.1E-01	5.8E-02	5.8E-02	5.5E-02	1.4E-05	5.8E-02	1.4E-05	6.1E-05	4.1E-03	5.3E-07	1.8E-06	1.4E-03	6.5E-06
>16-21 Aliphatics	1.1E-01	2.9E-03	2.9E-03	0.0E+00	0.0E+00	2.8E-03	0.0E+00	0.0E+00	0.0E+00	6.5E-11	0.0E+00	0.0E+00	7.9E-10
>5-7 Aromatics	2.7E-05	1.4E-03	1.4E-03	1.5E-03	4.2E-05	1.5E-03	4.2E-05	3.9E-03	1.3E-02	8.0E-02	1.9E-04	1.2E-01	4.0E-03
>7-8 Aromatics	2.3E-04	6.1E-05	6.1E-05	2.9E-04	5.1E-06	7.2E-05	5.1E-06	2.2E-04	1.1E-03	8.2E-04	9.6E-06	6.2E-03	1.7E-04
>8-10 Aromatics	1.1E-01	1.4E-01	1.4E-01	2.8E-01	3.1E-03	1.5E-01	3.1E-03	4.0E-02	3.1E-01	1.9E-01	1.6E-03	1.1E+00	4.0E-01
>10-12 Aromatics	1.1E-01	1.4E-01	1.4E-01	2.8E-01	1.7E-03	1.5E-01	1.7E-03	4.2E-03	5.8E-02	6.8E-02	2.4E-04	1.4E-01	4.0E-01
>12-16 Aromatics	1.1E-01	1.4E-01	1.4E-01	2.8E-01	5.3E-04	1.5E-01	5.3E-04	3.2E-04	1.1E-02	1.4E-02	2.9E-05	1.3E-02	1.6E-01
>16-21 Aromatics	1.1E-01	1.9E-01	1.9E-01	0.0E+00	0.0E+00	1.8E-01	0.0E+00	0.0E+00	0.0E+00	1.6E-03	0.0E+00	0.0E+00	1.9E-02
>21-35 Aromatics	1.1E-01	1.9E-01	1.9E-01	0.0E+00	0.0E+00	1.8E-01	0.0E+00	0.0E+00	0.0E+00	1.3E-05	0.0E+00	0.0E+00	1.6E-04
Total Hazard Index (HI) (ΣHQ_i)	1.0E+00	1.0E+00	1.0E+00	1.0E+00	5.5E-03	1.0E+00	5.5E-03	6.0E-02	1.0E+00	3.5E-01	2.3E-03	1.6E+00	1.0E+00
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.10E+05	6.95E+03	3.26E+11	7.08E+07	6.23E+03	7.08E+07	3.93E+05	1.63E+02	3.65E+03	1.76E+07	8.71E+03	1.52E+01
RBSL(C_{TPH}) (mg/kg)		100000	7000	3E+11	>Csat	6000	>Csat	>Csat	200	>Csat	>S	9000	20
Target Risk Level(HI)	1												
Use Raoult's Law(Yes/No?	yes												

Pathways:

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidental ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater
subsurface soil leaching to gw ingestion = ingestion of groundwater that contains contaminants leaching from subsurface soil

Table A-4: TPH Composition Data using TPHCWG Direct Method for Sample IRP4B02S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): IRP4B02S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.111	0.0555	3.66E-02	4.69E-04	7.14E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	1.84E-01	8.09E-04	1.23E-01
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.67	0.335	2.21E-01	8.76E-04	1.33E-01
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	1.84E-01	7.32E-04	1.11E-01
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	1.84E-01	7.32E-04	1.11E-01
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	1.84E-01	8.09E-04	1.23E-01
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	1.84E-01	6.64E-04	1.01E-01
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	1.84E-01	6.68E-04	1.02E-01
	TPH fractions							
	C>5-C6 aliphatics	8.10E+01	<	0.22	0.11	7.25E-02	8.95E-04	1.36E-01
	C>6-C8 aliphatics	1.00E+02		6.6	6.6	4.35E+00	4.35E-02	6.62E+00
	C>8-C10 aliphatics	1.30E+02		38	38	2.50E+01	1.93E-01	2.93E+01
	C>10-C12 aliphatics	1.60E+02		30	30	1.98E+01	1.24E-01	1.88E+01
	C>12-C16 aliphatics	2.00E+02	<	22	11	7.25E+00	3.62E-02	5.52E+00
	C >16-C21aliphatics	2.70E+02	<	22	11	7.25E+00	2.68E-02	4.09E+00
	C>5-C7 aromatics	7.80E+01	<	0.056	0.028	1.84E-02	2.37E-04	3.60E-02
	C>7-C8 aromatics	9.21E+01	<	0.056	0.028	1.84E-02	2.00E-04	3.05E-02
	C >8 - C10 aromatics	1.20E+02	<	22	11	7.25E+00	6.04E-02	9.20E+00
	C>10-C12 aromatics	1.30E+02	<	22	11	7.25E+00	5.58E-02	8.49E+00
	C>12-C16 aromatics	1.50E+02	<	22	11	7.25E+00	4.83E-02	7.36E+00
	C>16-C21 aromatics	1.90E+02	<	22	11	7.25E+00	3.81E-02	5.81E+00
	C>21-C35 aromatics	2.40E+02	<	22	11	7.25E+00	3.02E-02	4.60E+00

Total TPH fractions		*Sum of weight %*	6.57E-01
aliphatics	96.71	100	
aromatics	55.056		
Total	151.766		

Table A-5: TPH Fraction RBSLs using TPHCWG Direct Method for Sample IRP4B02S5-6P

	C_{ieut} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
>5-6 Aliphatics	4.7E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	4.1E+03	6.1E+01	8.1E+04	1.0E+04	1.4E+01	5.1E+02
>6-8 Aliphatics	2.6E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	9.8E+03	1.5E+02	2.9E+05	6.8E+03	9.3E+00	5.1E+02
>8-10 Aliphatics	1.4E+02	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	2.3E+03	3.4E+01	4.1E+04	2.3E+02	3.2E-01	1.0E+01
>10-12 Aliphatics	8.6E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	1.2E+04	1.8E+02	3.1E+05	1.5E+02	2.1E-01	1.0E+01
>12-16 Aliphatics	3.8E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	5.4E+04	8.1E+02	6.2E+06	3.6E+01	4.9E-02	1.0E+01
>16-21 Aliphatics	1.6E+01	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	1.6E+10	No RfC	No RfC	2.0E+02
>5-7 Aromatics	1.6E+03	2.0E+03	1.3E+02	5.7E+09	2.2E+03	1.2E+02	2.2E+03	2.3E+01	3.5E-01	1.1E+00	5.2E+02	8.4E-01	1.0E-01
>7-8 Aromatics	1.3E+03	4.1E+05	2.6E+04	2.5E+11	9.7E+04	1.9E+04	9.7E+04	2.3E+03	3.4E+01	6.1E+02	2.1E+04	3.3E+01	2.0E+01
>8-10 Aromatics	1.0E+03	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	3.7E+03	5.6E+01	7.9E+02	6.1E+03	8.9E+00	4.1E+00
>10-12 Aromatics	6.3E+02	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	2.0E+04	3.0E+02	1.2E+03	1.4E+04	2.4E+01	4.1E+00
>12-16 Aromatics	2.9E+02	8.2E+04	5.2E+03	1.3E+11	6.4E+04	4.5E+03	6.4E+04	1.1E+05	1.6E+03	2.5E+03	2.3E+04	5.1E+01	4.1E+00
>16-21 Aromatics	1.0E+02	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	5.9E+03	No RfC	No RfC	3.1E+00
>21-35 Aromatics	8.3E+00	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	4.7E+04	No RfC	No RfC	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
>5-6 Aliphatics	7.2E-04	9.3E-06	9.3E-06	2.4E-05	1.4E-07	1.0E-05	1.4E-07	1.6E-04	1.1E-03	7.9E-06	4.7E-06	2.6E-03	3.3E-05
>6-8 Aliphatics	4.3E-02	5.6E-04	5.6E-04	1.5E-03	3.8E-06	6.0E-04	3.8E-06	1.7E-03	2.8E-02	5.8E-05	5.2E-05	3.9E-02	7.0E-04
>8-10 Aliphatics	2.5E-01	1.6E-01	1.6E-01	1.5E-01	1.7E-04	1.6E-01	1.7E-04	1.8E-02	6.8E-01	1.0E-03	5.4E-04	4.0E-01	1.2E-02
>10-12 Aliphatics	2.0E-01	1.3E-01	1.3E-01	1.2E-01	6.6E-05	1.3E-01	6.6E-05	1.4E-03	9.2E-02	5.2E-05	4.1E-05	3.0E-02	6.3E-04
>12-16 Aliphatics	7.2E-02	4.7E-02	4.6E-02	4.5E-02	8.6E-06	4.6E-02	8.6E-06	3.9E-05	2.6E-03	3.4E-07	1.2E-06	8.6E-04	4.1E-06
>16-21 Aliphatics	7.2E-02	2.3E-03	2.3E-03	0.0E+00	0.0E+00	2.2E-03	0.0E+00	0.0E+00	0.0E+00	4.1E-11	0.0E+00	0.0E+00	5.0E-10
>5-7 Aromatics	1.8E-04	1.2E-02	1.2E-02	1.3E-02	2.7E-04	1.2E-02	2.7E-04	2.5E-02	4.9E-02	5.2E-01	1.2E-03	1.1E-02	4.2E-02
>7-8 Aromatics	1.8E-04	5.9E-05	5.9E-05	2.9E-04	4.0E-06	7.0E-05	4.0E-06	1.7E-04	5.0E-04	6.3E-04	7.4E-06	2.8E-04	2.1E-04
>8-10 Aromatics	7.2E-02	1.2E-01	1.2E-01	2.2E-01	2.0E-03	1.2E-01	2.0E-03	2.6E-02	1.2E-01	1.2E-01	9.8E-04	4.1E-01	4.2E-01
>10-12 Aromatics	7.2E-02	1.2E-01	1.2E-01	2.2E-01	1.1E-03	1.2E-01	1.1E-03	2.6E-03	2.2E-02	4.3E-02	1.5E-04	8.7E-02	4.2E-01
>12-16 Aromatics	7.2E-02	1.2E-01	1.2E-01	2.2E-01	3.4E-04	1.2E-01	3.4E-04	2.0E-04	4.3E-03	8.6E-03	1.9E-05	8.4E-03	1.0E-01
>16-21 Aromatics	7.2E-02	1.6E-01	1.5E-01	0.0E+00	0.0E+00	1.5E-01	0.0E+00	0.0E+00	0.0E+00	1.0E-03	0.0E+00	0.0E+00	1.2E-02
>21-35 Aromatics	7.2E-02	1.6E-01	1.5E-01	0.0E+00	0.0E+00	1.5E-01	0.0E+00	0.0E+00	0.0E+00	8.2E-06	0.0E+00	0.0E+00	9.9E-05
Total Hazard Index (HI) (ΣHQ_i)	1.0E+00	1.0E+00	1.0E+00	1.0E+00	3.9E-03	1.0E+00	3.9E-03	7.5E-02	1.0E+00	6.9E-01	3.0E-03	9.9E-01	1.0E+00
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.31E+05	8.29E+03	3.92E+11	7.08E+07	7.43E+03	7.08E+07	3.93E+05	9.31E+01	3.40E+03	1.76E+07	5.02E+01	2.35E+01
RBSL(C_{TPH}) (mg/kg)		100000	80000	4.E+11	> C_{sat}	7000	> C_{sat}	> C_{sat}	90	> C_{sat}	>S	50	20

Target Risk Level(HI) 1
Use Raoult's Law(Yes/No? yes

Pathways:

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater
subsurface soil leaching to gw ingestion = ingestion of groundwater that contains contaminants leaching from subsurface soil

Table A-6: TPH Composition Data using TPHCWG Direct Method for Sample IRP4B03S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): IRP4B03S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.126	0.063	1.10E-02	1.41E-04	2.24E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.55	0.275	4.79E-02	2.10E-04	3.35E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.66	0.33	5.74E-02	2.28E-04	3.64E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.55	0.275	4.79E-02	1.90E-04	3.03E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.55	0.275	4.79E-02	1.90E-04	3.03E-02
218-01-9	Chrysene	2.28E+02	<	0.55	0.275	4.79E-02	2.10E-04	3.35E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.55	0.275	4.79E-02	1.72E-04	2.75E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.55	0.275	4.79E-02	1.73E-04	2.77E-02
	TPH fractions							
	C>5-C6 aliphatics	8.10E+01	<	4.4	2.2	3.83E-01	4.73E-03	7.54E-01
	C>6-C8 aliphatics	1.00E+02	<	4.4	2.2	3.83E-01	3.83E-03	6.11E-01
	C>8-C10 aliphatics	1.30E+02		100	100	1.74E+01	1.34E-01	2.14E+01
	C>10-C12 aliphatics	1.60E+02		140	140	2.44E+01	1.52E-01	2.43E+01
	C>12-C16 aliphatics	2.00E+02		170	170	2.96E+01	1.48E-01	2.36E+01
	C >16-C21aliphatics	2.70E+02	<	22	11	1.91E+00	7.09E-03	1.13E+00
	C>5-C7 aromatics	7.80E+01	<	0.11	0.055	9.57E-03	1.23E-04	1.96E-02
	C>7-C8 aromatics	9.21E+01	<	0.11	0.055	9.57E-03	1.04E-04	1.66E-02
	C >8 - C10 aromatics	1.20E+02	<	22	11	1.91E+00	1.60E-02	2.54E+00
	C>10-C12 aromatics	1.30E+02		47	47	8.18E+00	6.29E-02	1.00E+01
	C>12-C16 aromatics	1.50E+02		69	69	1.20E+01	8.01E-02	1.28E+01
	C>16-C21 aromatics	1.90E+02	<	22	11	1.91E+00	1.01E-02	1.61E+00
	C>21-C35 aromatics	2.40E+02	<	22	11	1.91E+00	7.98E-03	1.27E+00

Total TPH fractions		*Sum of weight %*	6.27E-01
aliphatics	425.4	100	
aromatics	149.11		
Total	574.51		

Table A-7: TPH Fraction RBSLs using TPHCWG Direct Method for Sample IRP4B03S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
>5-6 Aliphatics	4.7E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	4.1E+03	6.1E+01	8.1E+04	1.0E+04	1.4E+01	5.1E+02
>6-8 Aliphatics	2.6E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	9.8E+03	1.5E+02	2.9E+05	6.8E+03	9.3E+00	5.1E+02
>8-10 Aliphatics	1.4E+02	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	2.3E+03	3.4E+01	4.1E+04	2.3E+02	3.2E-01	1.0E+01
>10-12 Aliphatics	8.6E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	1.2E+04	1.8E+02	3.1E+05	1.5E+02	2.1E-01	1.0E+01
>12-16 Aliphatics	3.8E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	5.4E+04	8.1E+02	6.2E+06	3.6E+01	4.9E-02	1.0E+01
>16-21 Aliphatics	1.6E+01	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	1.6E+10	No RfC	No RfC	2.0E+02
>5-7 Aromatics	1.6E+03	2.0E+03	1.3E+02	5.7E+09	2.2E+03	1.2E+02	2.2E+03	2.3E+01	3.5E-01	1.1E+00	5.2E+02	8.4E-01	1.0E-01
>7-8 Aromatics	1.3E+03	4.1E+05	2.6E+04	2.5E+11	9.7E+04	1.9E+04	9.7E+04	2.3E+03	3.4E+01	6.1E+02	2.1E+04	3.3E+01	2.0E+01
>8-10 Aromatics	1.0E+03	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	3.7E+03	5.6E+01	7.9E+02	6.1E+03	8.9E+00	4.1E+00
>10-12 Aromatics	6.3E+02	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	2.0E+04	3.0E+02	1.2E+03	1.4E+04	2.4E+01	4.1E+00
>12-16 Aromatics	2.9E+02	8.2E+04	5.2E+03	1.3E+11	6.4E+04	4.5E+03	6.4E+04	1.1E+05	1.6E+03	2.5E+03	2.3E+04	5.1E+01	4.1E+00
>16-21 Aromatics	1.0E+02	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	5.9E+03	No RfC	No RfC	3.1E+00
>21-35 Aromatics	8.3E+00	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	4.7E+04	No RfC	No RfC	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
>5-6 Aliphatics	3.8E-03	5.5E-05	5.5E-05	1.1E-04	7.9E-07	5.8E-05	7.9E-07	8.7E-04	8.9E-03	4.4E-05	2.6E-05	1.9E-02	2.6E-04
>6-8 Aliphatics	3.8E-03	5.5E-05	5.5E-05	1.1E-04	3.5E-07	5.8E-05	3.5E-07	1.6E-04	3.7E-03	5.3E-06	4.8E-06	3.6E-03	6.5E-05
>8-10 Aliphatics	1.7E-01	1.2E-01	1.2E-01	9.5E-02	1.2E-04	1.2E-01	1.2E-04	1.3E-02	7.2E-01	7.4E-04	4.0E-04	2.9E-01	9.0E-03
>10-12 Aliphatics	2.4E-01	1.7E-01	1.7E-01	1.3E-01	8.6E-05	1.7E-01	8.6E-05	1.8E-03	1.2E-01	6.7E-05	5.3E-05	3.9E-02	8.1E-04
>12-16 Aliphatics	3.0E-01	2.1E-01	2.1E-01	1.6E-01	3.7E-05	2.1E-01	3.7E-05	1.7E-04	1.1E-02	1.4E-06	5.0E-06	3.7E-03	1.8E-05
>16-21 Aliphatics	1.9E-02	6.8E-04	6.8E-04	0.0E+00	0.0E+00	6.4E-04	0.0E+00	0.0E+00	0.0E+00	1.1E-11	0.0E+00	0.0E+00	1.4E-10
>5-7 Aromatics	9.6E-05	6.8E-03	6.8E-03	5.8E-03	1.5E-04	6.8E-03	1.5E-04	1.4E-02	3.9E-02	2.8E-01	6.7E-04	3.4E-01	3.2E-02
>7-8 Aromatics	9.6E-05	3.4E-05	3.4E-05	1.3E-04	2.1E-06	4.0E-05	2.1E-06	9.1E-05	4.0E-04	3.4E-04	4.0E-06	2.6E-03	1.6E-04
>8-10 Aromatics	1.9E-02	3.4E-02	3.4E-02	5.2E-02	5.4E-04	3.5E-02	5.4E-04	7.1E-03	4.9E-02	3.3E-02	2.7E-04	1.9E-01	1.6E-01
>10-12 Aromatics	8.2E-02	1.5E-01	1.5E-01	2.2E-01	1.3E-03	1.5E-01	1.3E-03	3.1E-03	3.9E-02	5.1E-02	1.8E-04	1.0E-01	6.1E-01
>12-16 Aromatics	1.2E-01	2.1E-01	2.1E-01	3.3E-01	5.8E-04	2.2E-01	5.8E-04	3.5E-04	1.1E-02	1.5E-02	3.2E-05	1.5E-02	1.8E-01
>16-21 Aromatics	1.9E-02	4.5E-02	4.5E-02	0.0E+00	0.0E+00	4.3E-02	0.0E+00	0.0E+00	0.0E+00	2.8E-04	0.0E+00	0.0E+00	3.4E-03
>21-35 Aromatics	1.9E-02	4.5E-02	4.5E-02	0.0E+00	0.0E+00	4.3E-02	0.0E+00	0.0E+00	0.0E+00	2.3E-06	0.0E+00	0.0E+00	2.7E-05
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	2.8E-03	1.0E+00	2.8E-03	4.0E-02	1.0E+00	3.8E-01	1.6E-03	1.0E+00	1.0E+00
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.46E+05	9.21E+03	3.47E+11	7.08E+07	8.17E+03	7.08E+07	3.93E+05	1.42E+02	3.40E+03	1.76E+07	2.96E+03	3.40E+01
RBSL(C_{TPH}) (mg/kg)		100000	9000	3.E+11	> C_{sat}	8000	> C_{sat}	> C_{sat}	100	> C_{sat}	>S	3000	30

Target Risk Level(HI) 1
Use Raoult's Law(Yes/No? yes
Pathways:
surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater
subsurface soil leaching to gw ingestion = ingestion of groundwater that contains contaminants leaching from subsurface soil

Table A-8: TPH Composition Data using TPHCWG Direct Method for Sample IRP4B04S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): IRP4B04S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.137	0.0685	6.31E-02	8.09E-04	1.25E-01
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	2.58E-01	1.13E-03	1.75E-01
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.67	0.335	3.09E-01	1.22E-03	1.90E-01
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	2.58E-01	1.02E-03	1.59E-01
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	2.58E-01	1.02E-03	1.59E-01
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	2.58E-01	1.13E-03	1.75E-01
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	2.58E-01	9.28E-04	1.44E-01
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	2.58E-01	9.35E-04	1.45E-01
	TPH fractions							
	C>5-C6 aliphatics	8.10E+01	<	2.2	1.1	1.01E+00	1.25E-02	1.94E+00
	C>6-C8 aliphatics	1.00E+02		8.4	8.4	7.74E+00	7.74E-02	1.20E+01
	C>8-C10 aliphatics	1.30E+02	<	22	11	1.01E+01	7.79E-02	1.21E+01
	C>10-C12 aliphatics	1.60E+02	<	22	11	1.01E+01	6.33E-02	9.81E+00
	C>12-C16 aliphatics	2.00E+02	<	22	11	1.01E+01	5.07E-02	7.85E+00
	C >16-C21aliphatics	2.70E+02	<	22	11	1.01E+01	3.75E-02	5.81E+00
	C>5-C7 aromatics	7.80E+01	<	0.056	0.028	2.58E-02	3.31E-04	5.12E-02
	C>7-C8 aromatics	9.21E+01	<	0.056	0.028	2.58E-02	2.80E-04	4.34E-02
	C >8 - C10 aromatics	1.20E+02	<	22	11	1.01E+01	8.44E-02	1.31E+01
	C>10-C12 aromatics	1.30E+02	<	22	11	1.01E+01	7.79E-02	1.21E+01
	C>12-C16 aromatics	1.50E+02	<	22	11	1.01E+01	6.76E-02	1.05E+01
	C>16-C21 aromatics	1.90E+02	<	22	11	1.01E+01	5.33E-02	8.26E+00
	C>21-C35 aromatics	2.40E+02	<	22	11	1.01E+01	4.22E-02	6.54E+00

Total TPH fractions		*Sum of weight %*	6.45E-01
aliphatics	53.5	100	
aromatics	55.056		
Total	108.556		

Table A-9: TPH Fraction RBSLs using TPHCWG Direct Method for Sample IRP4B04S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
>5-6 Aliphatics	4.7E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	4.1E+03	6.1E+01	8.1E+04	1.0E+04	1.4E+01	5.1E+02
>6-8 Aliphatics	2.6E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	9.8E+03	1.5E+02	2.9E+05	6.8E+03	9.3E+00	5.1E+02
>8-10 Aliphatics	1.4E+02	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	2.3E+03	3.4E+01	4.1E+04	2.3E+02	3.2E-01	1.0E+01
>10-12 Aliphatics	8.6E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	1.2E+04	1.8E+02	3.1E+05	1.5E+02	2.1E-01	1.0E+01
>12-16 Aliphatics	3.8E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	5.4E+04	8.1E+02	6.2E+06	3.6E+01	4.9E-02	1.0E+01
>16-21 Aliphatics	1.6E+01	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	1.6E+10	No RfC	No RfC	2.0E+02
>5-7 Aromatics	1.6E+03	2.0E+03	1.3E+02	5.7E+09	2.2E+03	1.2E+02	2.2E+03	2.3E+01	3.5E-01	1.1E+00	5.2E+02	8.4E-01	1.0E-01
>7-8 Aromatics	1.3E+03	4.1E+05	2.6E+04	2.5E+11	9.7E+04	1.9E+04	9.7E+04	2.3E+03	3.4E+01	6.1E+02	2.1E+04	3.3E+01	2.0E+01
>8-10 Aromatics	1.0E+03	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	3.7E+03	5.6E+01	7.9E+02	6.1E+03	8.9E+00	4.1E+00
>10-12 Aromatics	6.3E+02	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	2.0E+04	3.0E+02	1.2E+03	1.4E+04	2.4E+01	4.1E+00
>12-16 Aromatics	2.9E+02	8.2E+04	5.2E+03	1.3E+11	6.4E+04	4.5E+03	6.4E+04	1.1E+05	1.6E+03	2.5E+03	2.3E+04	5.1E+01	4.1E+00
>16-21 Aromatics	1.0E+02	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	5.9E+03	No RfC	No RfC	3.1E+00
>21-35 Aromatics	8.3E+00	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	4.7E+04	No RfC	No RfC	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
>5-6 Aliphatics	1.0E-02	1.1E-04	1.1E-04	3.0E-04	2.0E-06	1.2E-04	2.0E-06	2.2E-03	2.4E-02	1.1E-04	6.8E-05	3.6E-02	3.1E-04
>6-8 Aliphatics	7.7E-02	8.7E-04	8.7E-04	2.3E-03	6.9E-06	9.5E-04	6.9E-06	3.1E-03	7.6E-02	1.0E-04	9.5E-05	7.0E-02	1.3E-03
>8-10 Aliphatics	1.0E-01	5.7E-02	5.7E-02	5.5E-02	7.0E-05	5.7E-02	7.0E-05	7.4E-03	4.2E-01	4.2E-04	2.2E-04	1.6E-01	5.1E-03
>10-12 Aliphatics	1.0E-01	5.7E-02	5.7E-02	5.5E-02	3.5E-05	5.7E-02	3.5E-05	7.1E-04	4.8E-02	2.7E-05	2.2E-05	1.6E-02	3.3E-04
>12-16 Aliphatics	1.0E-01	5.7E-02	5.7E-02	5.5E-02	1.2E-05	5.7E-02	1.2E-05	5.5E-05	3.7E-03	4.8E-07	1.7E-06	1.2E-03	5.8E-06
>16-21 Aliphatics	1.0E-01	2.9E-03	2.9E-03	0.0E+00	0.0E+00	2.7E-03	0.0E+00	0.0E+00	0.0E+00	5.9E-11	0.0E+00	0.0E+00	7.1E-10
>5-7 Aromatics	2.6E-04	1.5E-02	1.5E-02	1.5E-02	3.8E-04	1.5E-02	3.8E-04	3.6E-02	1.1E-01	7.4E-01	1.8E-03	1.5E-02	4.0E-02
>7-8 Aromatics	2.6E-04	7.3E-05	7.3E-05	3.5E-04	5.6E-06	8.7E-05	5.6E-06	2.4E-04	1.1E-03	9.0E-04	1.1E-05	3.9E-04	2.0E-04
>8-10 Aromatics	1.0E-01	1.4E-01	1.4E-01	2.7E-01	2.8E-03	1.5E-01	2.8E-03	3.6E-02	2.6E-01	1.7E-01	1.4E-03	5.6E-01	3.9E-01
>10-12 Aromatics	1.0E-01	1.4E-01	1.4E-01	2.7E-01	1.6E-03	1.5E-01	1.6E-03	3.8E-03	4.8E-02	6.1E-02	2.2E-04	1.2E-01	3.9E-01
>12-16 Aromatics	1.0E-01	1.4E-01	1.4E-01	2.7E-01	4.8E-04	1.5E-01	4.8E-04	2.9E-04	9.2E-03	1.2E-02	2.6E-05	1.2E-02	1.5E-01
>16-21 Aromatics	1.0E-01	1.9E-01	1.9E-01	0.0E+00	0.0E+00	1.8E-01	0.0E+00	0.0E+00	0.0E+00	1.4E-03	0.0E+00	0.0E+00	1.8E-02
>21-35 Aromatics	1.0E-01	1.9E-01	1.9E-01	0.0E+00	0.0E+00	1.8E-01	0.0E+00	0.0E+00	0.0E+00	1.2E-05	0.0E+00	0.0E+00	1.4E-04
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	5.3E-03	1.0E+00	5.3E-03	9.0E-02	1.0E+00	9.8E-01	3.8E-03	1.0E+00	1.0E+00
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.15E+05	7.30E+03	3.42E+11	7.08E+07	6.54E+03	7.08E+07	3.93E+05	1.44E+02	3.40E+03	1.76E+07	4.95E+01	1.59E+01
RBSL(C_{TPH}) (mg/kg)		100000	7000	3.E+11	>C_{sat}	7000	>C_{sat}	>C_{sat}	100	>C_{sat}	>S	50	20

Target Risk Level(HI) 1
Use Raoult's Law(Yes/No? yes
Pathways:
surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater
subsurface soil leaching to gw ingestion = ingestion of groundwater that contains contaminants leaching from subsurface soil

Table A-10: TPH Composition Data using TPHCWG Direct Method for Sample IRP4B08S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): IRP4B08S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.136	0.068	1.83E-02	2.35E-04	3.38E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.55	0.275	7.42E-02	3.25E-04	4.67E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.66	0.33	8.90E-02	3.53E-04	5.07E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.55	0.275	7.42E-02	2.94E-04	4.23E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.55	0.275	7.42E-02	2.94E-04	4.23E-02
218-01-9	Chrysene	2.28E+02	<	0.55	0.275	7.42E-02	3.25E-04	4.67E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.55	0.275	7.42E-02	2.67E-04	3.83E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.55	0.275	7.42E-02	2.69E-04	3.86E-02
	TPH fractions							
	C>5-C6 aliphatics	8.10E+01	<	8.8	4.4	1.19E+00	1.47E-02	2.10E+00
	C>6-C8 aliphatics	1.00E+02		45	45	1.21E+01	1.21E-01	1.74E+01
	C>8-C10 aliphatics	1.30E+02		98	98	2.64E+01	2.03E-01	2.92E+01
	C>10-C12 aliphatics	1.60E+02		89	89	2.40E+01	1.50E-01	2.16E+01
	C>12-C16 aliphatics	2.00E+02		57	57	1.54E+01	7.69E-02	1.10E+01
	C >16-C21aliphatics	2.70E+02	<	22	11	2.97E+00	1.10E-02	1.58E+00
	C>5-C7 aromatics	7.80E+01	<	0.22	0.11	2.97E-02	3.81E-04	5.46E-02
	C>7-C8 aromatics	9.21E+01	<	0.22	0.11	2.97E-02	3.22E-04	4.63E-02
	C >8 - C10 aromatics	1.20E+02	<	22	11	2.97E+00	2.47E-02	3.55E+00
	C>10-C12 aromatics	1.30E+02		22	22	5.94E+00	4.57E-02	6.56E+00
	C>12-C16 aromatics	1.50E+02	<	22	11	2.97E+00	1.98E-02	2.84E+00
	C>16-C21 aromatics	1.90E+02	<	22	11	2.97E+00	1.56E-02	2.24E+00
	C>21-C35 aromatics	2.40E+02	<	22	11	2.97E+00	1.24E-02	1.78E+00

Total TPH fractions		*Sum of weight %*	6.96E-01
aliphatics	304.4	100	
aromatics	66.22		
Total	370.62		

Table A-11: TPH Fraction RBSLs using TPHCWG Direct Method for Sample IRP4B08S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
>5-6 Aliphatics	4.7E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	4.1E+03	6.1E+01	8.1E+04	1.0E+04	1.4E+01	5.1E+02
>6-8 Aliphatics	2.6E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	9.8E+03	1.5E+02	2.9E+05	6.8E+03	9.3E+00	5.1E+02
>8-10 Aliphatics	1.4E+02	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	2.3E+03	3.4E+01	4.1E+04	2.3E+02	3.2E-01	1.0E+01
>10-12 Aliphatics	8.6E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	1.2E+04	1.8E+02	3.1E+05	1.5E+02	2.1E-01	1.0E+01
>12-16 Aliphatics	3.8E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	5.4E+04	8.1E+02	6.2E+06	3.6E+01	4.9E-02	1.0E+01
>16-21 Aliphatics	1.6E+01	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	1.6E+10	No RfC	No RfC	2.0E+02
>5-7 Aromatics	1.6E+03	2.0E+03	1.3E+02	5.7E+09	2.2E+03	1.2E+02	2.2E+03	2.3E+01	3.5E-01	1.1E+00	5.2E+02	8.4E-01	1.0E-01
>7-8 Aromatics	1.3E+03	4.1E+05	2.6E+04	2.5E+11	9.7E+04	1.9E+04	9.7E+04	2.3E+03	3.4E+01	6.1E+02	2.1E+04	3.3E+01	2.0E+01
>8-10 Aromatics	1.0E+03	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	3.7E+03	5.6E+01	7.9E+02	6.1E+03	8.9E+00	4.1E+00
>10-12 Aromatics	6.3E+02	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	2.0E+04	3.0E+02	1.2E+03	1.4E+04	2.4E+01	4.1E+00
>12-16 Aromatics	2.9E+02	8.2E+04	5.2E+03	1.3E+11	6.4E+04	4.5E+03	6.4E+04	1.1E+05	1.6E+03	2.5E+03	2.3E+04	5.1E+01	4.1E+00
>16-21 Aromatics	1.0E+02	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	5.9E+03	No RfC	No RfC	3.1E+00
>21-35 Aromatics	8.3E+00	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	4.7E+04	No RfC	No RfC	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
>5-6 Aliphatics	1.2E-02	2.0E-04	2.0E-04	5.0E-04	2.2E-06	2.2E-04	2.2E-06	2.4E-03	1.7E-02	1.2E-04	7.3E-05	5.4E-02	1.2E-03
>6-8 Aliphatics	1.2E-01	2.0E-03	2.0E-03	5.1E-03	1.0E-05	2.2E-03	1.0E-05	4.6E-03	7.2E-02	1.5E-04	1.4E-04	1.0E-01	1.8E-03
>8-10 Aliphatics	2.6E-01	2.2E-01	2.2E-01	2.0E-01	1.7E-04	2.2E-01	1.7E-04	1.8E-02	6.6E-01	1.0E-03	5.4E-04	4.0E-01	1.2E-02
>10-12 Aliphatics	2.4E-01	2.0E-01	2.0E-01	1.9E-01	7.6E-05	2.0E-01	7.6E-05	1.6E-03	1.0E-01	5.9E-05	4.7E-05	3.5E-02	7.2E-04
>12-16 Aliphatics	1.5E-01	1.3E-01	1.3E-01	1.2E-01	1.7E-05	1.3E-01	1.7E-05	7.8E-05	5.2E-03	6.8E-07	2.3E-06	1.7E-03	8.2E-06
>16-21 Aliphatics	3.0E-02	1.3E-03	1.3E-03	0.0E+00	0.0E+00	1.2E-03	0.0E+00	0.0E+00	0.0E+00	1.6E-11	0.0E+00	0.0E+00	1.9E-10
>5-7 Aromatics	3.0E-04	2.5E-02	2.5E-02	2.6E-02	4.1E-04	2.5E-02	4.1E-04	3.8E-02	7.3E-02	7.9E-01	1.9E-03	7.8E-02	1.5E-01
>7-8 Aromatics	3.0E-04	1.3E-04	1.3E-04	5.7E-04	6.0E-06	1.5E-04	6.0E-06	2.5E-04	7.4E-04	9.6E-04	1.1E-05	2.0E-03	7.7E-04
>8-10 Aromatics	3.0E-02	6.3E-02	6.3E-02	1.1E-01	7.6E-04	6.5E-02	7.6E-04	9.9E-03	4.6E-02	4.7E-02	3.8E-04	2.6E-01	3.8E-01
>10-12 Aromatics	5.9E-02	1.3E-01	1.3E-01	2.3E-01	8.5E-04	1.3E-01	8.5E-04	2.0E-03	1.7E-02	3.3E-02	1.2E-04	6.7E-02	4.0E-01
>12-16 Aromatics	3.0E-02	6.3E-02	6.3E-02	1.1E-01	1.3E-04	6.4E-02	1.3E-04	7.8E-05	1.6E-03	3.3E-03	7.2E-06	3.2E-03	4.0E-02
>16-21 Aromatics	3.0E-02	8.3E-02	8.3E-02	0.0E+00	0.0E+00	7.9E-02	0.0E+00	0.0E+00	0.0E+00	3.9E-04	0.0E+00	0.0E+00	4.8E-03
>21-35 Aromatics	3.0E-02	8.3E-02	8.3E-02	0.0E+00	0.0E+00	7.9E-02	0.0E+00	0.0E+00	0.0E+00	3.2E-06	0.0E+00	0.0E+00	3.8E-05
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	2.4E-03	1.0E+00	2.4E-03	7.7E-02	1.0E+00	8.7E-01	3.2E-03	1.0E+00	1.0E+00
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.72E+05	1.09E+04	4.91E+11	7.08E+07	9.73E+03	7.08E+07	3.93E+05	8.63E+01	3.40E+03	1.76E+07	2.21E+02	5.28E+01
RBSL(C_{TPH}) (mg/kg)		200000	10000	5.E+11	>C_{sat}	10000	>C_{sat}	>C_{sat}	90	>C_{sat}	>S	200	50

Target Risk Level(HI) 1
Use Raoult's Law(Yes/No? yes
Pathways:
surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater
subsurface soil leaching to gw ingestion = ingestion of groundwater that contains contaminants leaching from subsurface soil

Table A-12: TPH Composition Data using TPHCWG Direct Method for Sample IRP4B09S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): IRP4B09S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.125	0.0625	1.51E-02	1.94E-04	3.07E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.55	0.275	6.66E-02	2.92E-04	4.63E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.66	0.33	7.99E-02	3.17E-04	5.02E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.55	0.275	6.66E-02	2.64E-04	4.18E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.55	0.275	6.66E-02	2.64E-04	4.18E-02
218-01-9	Chrysene	2.28E+02	<	0.55	0.275	6.66E-02	2.92E-04	4.63E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.55	0.275	6.66E-02	2.39E-04	3.79E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.55	0.275	6.66E-02	2.41E-04	3.82E-02
	TPH fractions							
	C>5-C6 aliphatics	8.10E+01	<	2.2	1.1	2.66E-01	3.29E-03	5.21E-01
	C>6-C8 aliphatics	1.00E+02		22	22	5.32E+00	5.32E-02	8.44E+00
	C>8-C10 aliphatics	1.30E+02		60	60	1.45E+01	1.12E-01	1.77E+01
	C>10-C12 aliphatics	1.60E+02		93	93	2.25E+01	1.41E-01	2.23E+01
	C>12-C16 aliphatics	2.00E+02		130	130	3.15E+01	1.57E-01	2.49E+01
	C >16-C21aliphatics	2.70E+02	<	22	11	2.66E+00	9.86E-03	1.56E+00
	C>5-C7 aromatics	7.80E+01	<	0.055	0.0275	6.66E-03	8.53E-05	1.35E-02
	C>7-C8 aromatics	9.21E+01	<	0.055	0.0275	6.66E-03	7.23E-05	1.14E-02
	C >8 - C10 aromatics	1.20E+02	<	22	11	2.66E+00	2.22E-02	3.52E+00
	C>10-C12 aromatics	1.30E+02		24	24	5.81E+00	4.47E-02	7.08E+00
	C>12-C16 aromatics	1.50E+02		39	39	9.44E+00	6.29E-02	9.97E+00
	C>16-C21 aromatics	1.90E+02	<	22	11	2.66E+00	1.40E-02	2.22E+00
	C>21-C35 aromatics	2.40E+02	<	22	11	2.66E+00	1.11E-02	1.76E+00

Total TPH fractions		*Sum of weight %*	6.31E-01
aliphatics	317.1	100	
aromatics	96.055		
Total	413.155		

Table A-13: TPH Fraction RBSLs using TPHCWG Direct Method for Sample IRP4B09S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
>5-6 Aliphatics	4.7E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	4.1E+03	6.1E+01	8.1E+04	1.0E+04	1.4E+01	5.1E+02
>6-8 Aliphatics	2.6E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	9.8E+03	1.5E+02	2.9E+05	6.8E+03	9.3E+00	5.1E+02
>8-10 Aliphatics	1.4E+02	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	2.3E+03	3.4E+01	4.1E+04	2.3E+02	3.2E-01	1.0E+01
>10-12 Aliphatics	8.6E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	1.2E+04	1.8E+02	3.1E+05	1.5E+02	2.1E-01	1.0E+01
>12-16 Aliphatics	3.8E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	5.4E+04	8.1E+02	6.2E+06	3.6E+01	4.9E-02	1.0E+01
>16-21 Aliphatics	1.6E+01	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	1.6E+10	No RfC	No RfC	2.0E+02
>5-7 Aromatics	1.6E+03	2.0E+03	1.3E+02	5.7E+09	2.2E+03	1.2E+02	2.2E+03	2.3E+01	3.5E-01	1.1E+00	5.2E+02	8.4E-01	1.0E-01
>7-8 Aromatics	1.3E+03	4.1E+05	2.6E+04	2.5E+11	9.7E+04	1.9E+04	9.7E+04	2.3E+03	3.4E+01	6.1E+02	2.1E+04	3.3E+01	2.0E+01
>8-10 Aromatics	1.0E+03	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	3.7E+03	5.6E+01	7.9E+02	6.1E+03	8.9E+00	4.1E+00
>10-12 Aromatics	6.3E+02	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	2.0E+04	3.0E+02	1.2E+03	1.4E+04	2.4E+01	4.1E+00
>12-16 Aromatics	2.9E+02	8.2E+04	5.2E+03	1.3E+11	6.4E+04	4.5E+03	6.4E+04	1.1E+05	1.6E+03	2.5E+03	2.3E+04	5.1E+01	4.1E+00
>16-21 Aromatics	1.0E+02	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	5.9E+03	No RfC	No RfC	3.1E+00
>21-35 Aromatics	8.3E+00	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	4.7E+04	No RfC	No RfC	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
>5-6 Aliphatics	2.7E-03	4.0E-05	4.0E-05	9.1E-05	5.5E-07	4.3E-05	5.5E-07	6.0E-04	6.9E-03	3.0E-05	1.8E-05	1.3E-02	3.0E-04
>6-8 Aliphatics	5.3E-02	8.1E-04	8.1E-04	1.8E-03	4.8E-06	8.7E-04	4.8E-06	2.2E-03	5.8E-02	7.4E-05	6.7E-05	4.9E-02	8.9E-04
>8-10 Aliphatics	1.5E-01	1.1E-01	1.1E-01	9.1E-02	1.0E-04	1.1E-01	1.0E-04	1.1E-02	6.7E-01	6.1E-04	3.3E-04	2.4E-01	7.4E-03
>10-12 Aliphatics	2.3E-01	1.7E-01	1.7E-01	1.4E-01	7.9E-05	1.7E-01	7.9E-05	1.6E-03	1.1E-01	6.1E-05	4.9E-05	3.6E-02	7.4E-04
>12-16 Aliphatics	3.1E-01	2.4E-01	2.4E-01	2.0E-01	3.9E-05	2.4E-01	3.9E-05	1.8E-04	1.2E-02	1.5E-06	5.3E-06	3.9E-03	1.9E-05
>16-21 Aliphatics	2.7E-02	1.0E-03	1.0E-03	0.0E+00	0.0E+00	9.6E-04	0.0E+00	0.0E+00	0.0E+00	1.6E-11	0.0E+00	0.0E+00	1.9E-10
>5-7 Aromatics	6.7E-05	5.0E-03	5.0E-03	4.6E-03	1.0E-04	5.0E-03	1.0E-04	9.4E-03	3.0E-02	1.9E-01	4.7E-04	2.9E-01	3.7E-02
>7-8 Aromatics	6.7E-05	2.5E-05	2.5E-05	1.0E-04	1.5E-06	3.0E-05	1.5E-06	6.3E-05	3.1E-04	2.4E-04	2.8E-06	1.8E-03	1.9E-04
>8-10 Aromatics	2.7E-02	5.0E-02	5.0E-02	8.4E-02	7.5E-04	5.3E-02	7.5E-04	9.8E-03	7.6E-02	4.6E-02	3.8E-04	2.6E-01	3.7E-01
>10-12 Aromatics	5.8E-02	1.1E-01	1.1E-01	1.8E-01	9.2E-04	1.1E-01	9.2E-04	2.2E-03	3.1E-02	3.6E-02	1.3E-04	7.3E-02	4.3E-01
>12-16 Aromatics	9.4E-02	1.8E-01	1.8E-01	3.0E-01	4.6E-04	1.8E-01	4.6E-04	2.7E-04	9.4E-03	1.2E-02	2.5E-05	1.1E-02	1.4E-01
>16-21 Aromatics	2.7E-02	6.7E-02	6.7E-02	0.0E+00	0.0E+00	6.4E-02	0.0E+00	0.0E+00	0.0E+00	3.9E-04	0.0E+00	0.0E+00	4.7E-03
>21-35 Aromatics	2.7E-02	6.7E-02	6.7E-02	0.0E+00	0.0E+00	6.4E-02	0.0E+00	0.0E+00	0.0E+00	3.1E-06	0.0E+00	0.0E+00	3.8E-05
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	2.4E-03	1.0E+00	2.4E-03	3.7E-02	1.0E+00	2.9E-01	1.5E-03	9.7E-01	1.0E+00
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.55E+05	9.81E+03	3.99E+11	7.08E+07	8.73E+03	7.08E+07	3.93E+05	1.59E+02	3.40E+03	1.76E+07	8.71E+03	5.74E+01
RBSL(C_{TPH}) (mg/kg)		200000	10000	4.E+11	> C_{sat}	9000	> C_{sat}	> C_{sat}	200	> C_{sat}	>S	>S	60

Target Risk Level(HI) 1
Use Raoult's Law(Yes/No? yes

Pathways:
surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater
subsurface soil leaching to gw ingestion = ingestion of groundwater that contains contaminants leaching from subsurface soil

Table A-14: TPH Composition Data using TPHCWG Direct Method for Sample IRP4B10S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): IRP4B10S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.125	0.0625	1.95E-02	2.51E-04	3.84E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	8.75E-02	3.84E-04	5.89E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.67	0.335	1.05E-01	4.16E-04	6.38E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	8.75E-02	3.47E-04	5.33E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	8.75E-02	3.47E-04	5.33E-02
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	8.75E-02	3.84E-04	5.89E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	8.75E-02	3.15E-04	4.83E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	8.75E-02	3.17E-04	4.87E-02
	TPH fractions							
	C>5-C6 aliphatics	8.10E+01	<	8.9	4.45	1.39E+00	1.72E-02	2.63E+00
	C>6-C8 aliphatics	1.00E+02		23	23	7.19E+00	7.19E-02	1.10E+01
	C>8-C10 aliphatics	1.30E+02		55	55	1.72E+01	1.32E-01	2.03E+01
	C>10-C12 aliphatics	1.60E+02		83	83	2.60E+01	1.62E-01	2.49E+01
	C>12-C16 aliphatics	2.00E+02		76	76	2.38E+01	1.19E-01	1.82E+01
	C >16-C21aliphatics	2.70E+02	<	22	11	3.44E+00	1.27E-02	1.95E+00
	C>5-C7 aromatics	7.80E+01	<	0.22	0.11	3.44E-02	4.41E-04	6.76E-02
	C>7-C8 aromatics	9.21E+01		0.26	0.26	8.13E-02	8.83E-04	1.35E-01
	C >8 - C10 aromatics	1.20E+02	<	22	11	3.44E+00	2.87E-02	4.40E+00
	C>10-C12 aromatics	1.30E+02	<	22	11	3.44E+00	2.65E-02	4.06E+00
	C>12-C16 aromatics	1.50E+02		23	23	7.19E+00	4.79E-02	7.35E+00
	C>16-C21 aromatics	1.90E+02	<	22	11	3.44E+00	1.81E-02	2.78E+00
	C>21-C35 aromatics	2.40E+02	<	22	11	3.44E+00	1.43E-02	2.20E+00

Total TPH fractions		*Sum of weight %*	6.52E-01
aliphatics	252.45	100	
aromatics	67.37		
Total	319.82		

Table A-15: TPH Fraction RBSLs using TPHCWG Direct Method for Sample IRP4B10S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
>5-6 Aliphatics	4.7E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	4.1E+03	6.1E+01	8.1E+04	1.0E+04	1.4E+01	5.1E+02
>6-8 Aliphatics	2.6E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	9.8E+03	1.5E+02	2.9E+05	6.8E+03	9.3E+00	5.1E+02
>8-10 Aliphatics	1.4E+02	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	2.3E+03	3.4E+01	4.1E+04	2.3E+02	3.2E-01	1.0E+01
>10-12 Aliphatics	8.6E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	1.2E+04	1.8E+02	3.1E+05	1.5E+02	2.1E-01	1.0E+01
>12-16 Aliphatics	3.8E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	5.4E+04	8.1E+02	6.2E+06	3.6E+01	4.9E-02	1.0E+01
>16-21 Aliphatics	1.6E+01	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	1.6E+10	No RfC	No RfC	2.0E+02
>5-7 Aromatics	1.6E+03	2.0E+03	1.3E+02	5.7E+09	2.2E+03	1.2E+02	2.2E+03	2.3E+01	3.5E-01	1.1E+00	5.2E+02	8.4E-01	1.0E-01
>7-8 Aromatics	1.3E+03	4.1E+05	2.6E+04	2.5E+11	9.7E+04	1.9E+04	9.7E+04	2.3E+03	3.4E+01	6.1E+02	2.1E+04	3.3E+01	2.0E+01
>8-10 Aromatics	1.0E+03	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	3.7E+03	5.6E+01	7.9E+02	6.1E+03	8.9E+00	4.1E+00
>10-12 Aromatics	6.3E+02	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	2.0E+04	3.0E+02	1.2E+03	1.4E+04	2.4E+01	4.1E+00
>12-16 Aromatics	2.9E+02	8.2E+04	5.2E+03	1.3E+11	6.4E+04	4.5E+03	6.4E+04	1.1E+05	1.6E+03	2.5E+03	2.3E+04	5.1E+01	4.1E+00
>16-21 Aromatics	1.0E+02	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	5.9E+03	No RfC	No RfC	3.1E+00
>21-35 Aromatics	8.3E+00	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	4.7E+04	No RfC	No RfC	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
>5-6 Aliphatics	1.4E-02	2.2E-04	2.2E-04	5.3E-04	2.8E-06	2.3E-04	2.8E-06	3.0E-03	2.6E-02	1.5E-04	9.2E-05	6.8E-02	1.5E-03
>6-8 Aliphatics	7.2E-02	1.1E-03	1.1E-03	2.8E-03	6.3E-06	1.2E-03	6.3E-06	2.9E-03	5.7E-02	9.6E-05	8.7E-05	6.4E-02	1.2E-03
>8-10 Aliphatics	1.7E-01	1.3E-01	1.3E-01	1.2E-01	1.2E-04	1.3E-01	1.2E-04	1.2E-02	5.8E-01	7.0E-04	3.8E-04	2.8E-01	8.5E-03
>10-12 Aliphatics	2.6E-01	2.0E-01	2.0E-01	1.8E-01	8.8E-05	2.0E-01	8.8E-05	1.8E-03	1.2E-01	6.8E-05	5.5E-05	4.0E-02	8.3E-04
>12-16 Aliphatics	2.4E-01	1.8E-01	1.8E-01	1.7E-01	2.9E-05	1.8E-01	2.9E-05	1.3E-04	8.6E-03	1.1E-06	3.9E-06	2.9E-03	1.4E-05
>16-21 Aliphatics	3.4E-02	1.3E-03	1.3E-03	0.0E+00	0.0E+00	1.3E-03	0.0E+00	0.0E+00	0.0E+00	2.0E-11	0.0E+00	0.0E+00	2.4E-10
>5-7 Aromatics	3.4E-04	2.7E-02	2.7E-02	2.7E-02	5.0E-04	2.7E-02	5.0E-04	4.7E-02	1.1E-01	9.7E-01	2.3E-03	1.4E+00	1.8E-01
>7-8 Aromatics	8.1E-04	3.2E-04	3.2E-04	1.4E-03	1.8E-05	3.7E-04	1.8E-05	7.4E-04	2.7E-03	2.8E-03	3.3E-05	2.1E-02	2.1E-03
>8-10 Aromatics	3.4E-02	6.7E-02	6.7E-02	1.2E-01	9.4E-04	7.0E-02	9.4E-04	1.2E-02	7.1E-02	5.8E-02	4.7E-04	3.2E-01	4.5E-01
>10-12 Aromatics	3.4E-02	6.7E-02	6.7E-02	1.2E-01	5.2E-04	7.0E-02	5.2E-04	1.3E-03	1.3E-02	2.0E-02	7.2E-05	4.2E-02	2.5E-01
>12-16 Aromatics	7.2E-02	1.4E-01	1.4E-01	2.5E-01	3.4E-04	1.4E-01	3.4E-04	2.0E-04	5.3E-03	8.6E-03	1.9E-05	8.4E-03	1.0E-01
>16-21 Aromatics	3.4E-02	8.9E-02	8.9E-02	0.0E+00	0.0E+00	8.5E-02	0.0E+00	0.0E+00	0.0E+00	4.9E-04	0.0E+00	0.0E+00	5.9E-03
>21-35 Aromatics	3.4E-02	8.9E-02	8.9E-02	0.0E+00	0.0E+00	8.5E-02	0.0E+00	0.0E+00	0.0E+00	3.9E-06	0.0E+00	0.0E+00	4.7E-05
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	2.6E-03	1.0E+00	2.6E-03	8.2E-02	1.0E+00	1.1E+00	3.5E-03	2.3E+00	1.0E+00
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.59E+05	1.00E+04	4.48E+11	7.08E+07	8.98E+03	7.08E+07	3.93E+05	1.16E+02	3.40E+03	1.76E+07	8.71E+03	5.33E+01
RBSL(C_{TPH}) (ng/kg)		200000	10000	4.E+11	>C_{sat}	9000	>C_{sat}	>C_{sat}	100	3000	>S	9000	50

Target Risk Level(HI) 1
Use Raoult's Law(Yes/No? yes

Pathways:
surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater
subsurface soil leaching to gw ingestion = ingestion of groundwater that contains contaminants leaching from subsurface soil

Table A-16: TPH Composition Data using TPHCWG Direct Method for Sample IRP4B12S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): IRP4B12S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.12	0.06	1.67E-02	2.15E-04	3.17E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.57	0.285	7.95E-02	3.49E-04	5.15E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.68	0.34	9.49E-02	3.76E-04	5.56E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.57	0.285	7.95E-02	3.16E-04	4.66E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.57	0.285	7.95E-02	3.16E-04	4.66E-02
218-01-9	Chrysene	2.28E+02	<	0.57	0.285	7.95E-02	3.49E-04	5.15E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.57	0.285	7.95E-02	2.86E-04	4.22E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.57	0.285	7.95E-02	2.88E-04	4.25E-02
	TPH fractions							
	C>5-C6 aliphatics	8.10E+01	<	4.5	2.25	6.28E-01	7.75E-03	1.14E+00
	C>6-C8 aliphatics	1.00E+02		33	33	9.21E+00	9.21E-02	1.36E+01
	C>8-C10 aliphatics	1.30E+02		100	100	2.79E+01	2.15E-01	3.17E+01
	C>10-C12 aliphatics	1.60E+02		94	94	2.62E+01	1.64E-01	2.42E+01
	C>12-C16 aliphatics	2.00E+02		60	60	1.67E+01	8.37E-02	1.24E+01
	C >16-C21aliphatics	2.70E+02	<	23	11.5	3.21E+00	1.19E-02	1.75E+00
	C>5-C7 aromatics	7.80E+01	<	0.11	0.055	1.53E-02	1.97E-04	2.90E-02
	C>7-C8 aromatics	9.21E+01	<	0.11	0.055	1.53E-02	1.67E-04	2.46E-02
	C >8 - C10 aromatics	1.20E+02	<	23	11.5	3.21E+00	2.67E-02	3.95E+00
	C>10-C12 aromatics	1.30E+02	<	23	11.5	3.21E+00	2.47E-02	3.64E+00
	C>12-C16 aromatics	1.50E+02	<	23	11.5	3.21E+00	2.14E-02	3.16E+00
	C>16-C21 aromatics	1.90E+02	<	23	11.5	3.21E+00	1.69E-02	2.49E+00
	C>21-C35 aromatics	2.40E+02	<	23	11.5	3.21E+00	1.34E-02	1.97E+00

Total TPH fractions		*Sum of weight %*	6.77E-01
aliphatics	300.75	100	
aromatics	57.61		
Total	358.36		

Table A-17: TPH Fraction RBSLs using TPHCWG Direct Method for Sample IRP4B12S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
>5-6 Aliphatics	4.7E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	4.1E+03	6.1E+01	8.1E+04	1.0E+04	1.4E+01	5.1E+02
>6-8 Aliphatics	2.6E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	9.8E+03	1.5E+02	2.9E+05	6.8E+03	9.3E+00	5.1E+02
>8-10 Aliphatics	1.4E+02	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	2.3E+03	3.4E+01	4.1E+04	2.3E+02	3.2E-01	1.0E+01
>10-12 Aliphatics	8.6E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	1.2E+04	1.8E+02	3.1E+05	1.5E+02	2.1E-01	1.0E+01
>12-16 Aliphatics	3.8E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	5.4E+04	8.1E+02	6.2E+06	3.6E+01	4.9E-02	1.0E+01
>16-21 Aliphatics	1.6E+01	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	1.6E+10	No RfC	No RfC	2.0E+02
>5-7 Aromatics	1.6E+03	2.0E+03	1.3E+02	5.7E+09	2.2E+03	1.2E+02	2.2E+03	2.3E+01	3.5E-01	1.1E+00	5.2E+02	8.4E-01	1.0E-01
>7-8 Aromatics	1.3E+03	4.1E+05	2.6E+04	2.5E+11	9.7E+04	1.9E+04	9.7E+04	2.3E+03	3.4E+01	6.1E+02	2.1E+04	3.3E+01	2.0E+01
>8-10 Aromatics	1.0E+03	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	3.7E+03	5.6E+01	7.9E+02	6.1E+03	8.9E+00	4.1E+00
>10-12 Aromatics	6.3E+02	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	2.0E+04	3.0E+02	1.2E+03	1.4E+04	2.4E+01	4.1E+00
>12-16 Aromatics	2.9E+02	8.2E+04	5.2E+03	1.3E+11	6.4E+04	4.5E+03	6.4E+04	1.1E+05	1.6E+03	2.5E+03	2.3E+04	5.1E+01	4.1E+00
>16-21 Aromatics	1.0E+02	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	5.9E+03	No RfC	No RfC	3.1E+00
>21-35 Aromatics	8.3E+00	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	4.7E+04	No RfC	No RfC	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
>5-6 Aliphatics	6.3E-03	1.1E-04	1.1E-04	2.8E-04	1.2E-06	1.1E-04	1.2E-06	1.3E-03	9.0E-03	6.7E-05	4.0E-05	2.9E-02	8.1E-04
>6-8 Aliphatics	9.2E-02	1.6E-03	1.6E-03	4.1E-03	7.8E-06	1.7E-03	7.8E-06	3.6E-03	5.5E-02	1.2E-04	1.1E-04	7.9E-02	1.4E-03
>8-10 Aliphatics	2.8E-01	2.4E-01	2.4E-01	2.3E-01	1.8E-04	2.4E-01	1.8E-04	1.9E-02	7.1E-01	1.1E-03	5.9E-04	4.3E-01	1.3E-02
>10-12 Aliphatics	2.6E-01	2.2E-01	2.2E-01	2.2E-01	8.5E-05	2.2E-01	8.5E-05	1.8E-03	1.2E-01	6.6E-05	5.3E-05	3.9E-02	8.1E-04
>12-16 Aliphatics	1.7E-01	1.4E-01	1.4E-01	1.4E-01	1.9E-05	1.4E-01	1.9E-05	8.7E-05	5.8E-03	7.6E-07	2.6E-06	1.9E-03	9.2E-06
>16-21 Aliphatics	3.2E-02	1.4E-03	1.4E-03	0.0E+00	0.0E+00	1.3E-03	0.0E+00	0.0E+00	0.0E+00	1.8E-11	0.0E+00	0.0E+00	2.1E-10
>5-7 Aromatics	1.5E-04	1.3E-02	1.3E-02	1.4E-02	2.2E-04	1.3E-02	2.2E-04	2.0E-02	3.9E-02	4.2E-01	1.0E-03	6.2E-01	1.1E-01
>7-8 Aromatics	1.5E-04	6.5E-05	6.5E-05	3.2E-04	3.2E-06	7.7E-05	3.2E-06	1.3E-04	3.9E-04	5.1E-04	6.0E-06	3.8E-03	5.7E-04
>8-10 Aromatics	3.2E-02	6.8E-02	6.8E-02	1.3E-01	8.4E-04	7.1E-02	8.4E-04	1.1E-02	5.0E-02	5.2E-02	4.2E-04	2.9E-01	6.0E-01
>10-12 Aromatics	3.2E-02	6.8E-02	6.8E-02	1.3E-01	4.7E-04	7.1E-02	4.7E-04	1.1E-03	9.3E-03	1.8E-02	6.5E-05	3.7E-02	2.2E-01
>12-16 Aromatics	3.2E-02	6.8E-02	6.8E-02	1.3E-01	1.4E-04	7.0E-02	1.4E-04	8.6E-05	1.8E-03	3.7E-03	8.0E-06	3.6E-03	4.5E-02
>16-21 Aromatics	3.2E-02	9.0E-02	9.0E-02	0.0E+00	0.0E+00	8.6E-02	0.0E+00	0.0E+00	0.0E+00	4.4E-04	0.0E+00	0.0E+00	5.3E-03
>21-35 Aromatics	3.2E-02	9.0E-02	9.0E-02	0.0E+00	0.0E+00	8.6E-02	0.0E+00	0.0E+00	0.0E+00	3.5E-06	0.0E+00	0.0E+00	4.2E-05
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	2.0E-03	1.0E+00	2.0E-03	5.9E-02	1.0E+00	4.9E-01	2.3E-03	1.5E+00	1.0E+00
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.73E+05	1.09E+04	5.23E+11	7.08E+07	9.80E+03	7.08E+07	3.93E+05	8.78E+01	3.40E+03	1.76E+07	8.71E+03	7.59E+01
RBSL(C_{TPH}) (mg/kg)		200000	10000	5.E+11	>C_{sat}	10000	>C_{sat}	>C_{sat}	90	>C_{sat}	>S	9000	80

Target Risk Level(HI) 1
Use Raoult's Law(Yes/No? yes
Pathways:
surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater
subsurface soil leaching to gw ingestion = ingestion of groundwater that contains contaminants leaching from subsurface soil

Table A-18: TPH Composition Data using TPHCWG Direct Method for Sample IRP4B14S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): IRP4B14S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.137	0.0685	3.54E-02	4.53E-04	7.08E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	1.45E-01	6.34E-04	9.90E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.68	0.34	1.75E-01	6.96E-04	1.09E-01
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	1.45E-01	5.74E-04	8.96E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	1.45E-01	5.74E-04	8.96E-02
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	1.45E-01	6.34E-04	9.90E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	1.45E-01	5.20E-04	8.12E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	1.45E-01	5.24E-04	8.18E-02
	TPH fractions							
	C>5-C6 aliphatics	8.10E+01	<	2.3	1.15	5.94E-01	7.33E-03	1.14E+00
	C>6-C8 aliphatics	1.00E+02		25	25	1.29E+01	1.29E-01	2.01E+01
	C>8-C10 aliphatics	1.30E+02	<	23	11.5	5.94E+00	4.57E-02	7.13E+00
	C>10-C12 aliphatics	1.60E+02		32	32	1.65E+01	1.03E-01	1.61E+01
	C>12-C16 aliphatics	2.00E+02		55	55	2.84E+01	1.42E-01	2.22E+01
	C >16-C21aliphatics	2.70E+02	<	23	11.5	5.94E+00	2.20E-02	3.43E+00
	C>5-C7 aromatics	7.80E+01		0.059	0.059	3.05E-02	3.90E-04	6.10E-02
	C>7-C8 aromatics	9.21E+01	<	0.056	0.028	1.45E-02	1.57E-04	2.45E-02
	C >8 - C10 aromatics	1.20E+02	<	23	11.5	5.94E+00	4.95E-02	7.72E+00
	C>10-C12 aromatics	1.30E+02	<	23	11.5	5.94E+00	4.57E-02	7.13E+00
	C>12-C16 aromatics	1.50E+02	<	23	11.5	5.94E+00	3.96E-02	6.18E+00
	C>16-C21 aromatics	1.90E+02	<	23	11.5	5.94E+00	3.12E-02	4.88E+00
	C>21-C35 aromatics	2.40E+02	<	23	11.5	5.94E+00	2.47E-02	3.86E+00

Total TPH fractions		*Sum of weight %*	6.40E-01
aliphatics	136.15	100	
aromatics	57.587		
Total	193.737		

Table A-19: TPH Fraction RBSLs using TPHCWG Direct Method for Sample IRP4B14S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
>5-6 Aliphatics	4.7E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	4.1E+03	6.1E+01	8.1E+04	1.0E+04	1.4E+01	5.1E+02
>6-8 Aliphatics	2.6E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	9.8E+03	1.5E+02	2.9E+05	6.8E+03	9.3E+00	5.1E+02
>8-10 Aliphatics	1.4E+02	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	2.3E+03	3.4E+01	4.1E+04	2.3E+02	3.2E-01	1.0E+01
>10-12 Aliphatics	8.6E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	1.2E+04	1.8E+02	3.1E+05	1.5E+02	2.1E-01	1.0E+01
>12-16 Aliphatics	3.8E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	5.4E+04	8.1E+02	6.2E+06	3.6E+01	4.9E-02	1.0E+01
>16-21 Aliphatics	1.6E+01	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	1.6E+10	No RfC	No RfC	2.0E+02
>5-7 Aromatics	1.6E+03	2.0E+03	1.3E+02	5.7E+09	2.2E+03	1.2E+02	2.2E+03	2.3E+01	3.5E-01	1.1E+00	5.2E+02	8.4E-01	1.0E-01
>7-8 Aromatics	1.3E+03	4.1E+05	2.6E+04	2.5E+11	9.7E+04	1.9E+04	9.7E+04	2.3E+03	3.4E+01	6.1E+02	2.1E+04	3.3E+01	2.0E+01
>8-10 Aromatics	1.0E+03	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	3.7E+03	5.6E+01	7.9E+02	6.1E+03	8.9E+00	4.1E+00
>10-12 Aromatics	6.3E+02	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	2.0E+04	3.0E+02	1.2E+03	1.4E+04	2.4E+01	4.1E+00
>12-16 Aromatics	2.9E+02	8.2E+04	5.2E+03	1.3E+11	6.4E+04	4.5E+03	6.4E+04	1.1E+05	1.6E+03	2.5E+03	2.3E+04	5.1E+01	4.1E+00
>16-21 Aromatics	1.0E+02	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	5.9E+03	No RfC	No RfC	3.1E+00
>21-35 Aromatics	8.3E+00	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	4.7E+04	No RfC	No RfC	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
>5-6 Aliphatics	5.9E-03	8.6E-05	8.6E-05	2.2E-04	1.2E-06	9.3E-05	1.2E-06	1.3E-03	1.9E-02	6.7E-05	4.0E-05	2.9E-02	3.2E-04
>6-8 Aliphatics	1.3E-01	1.9E-03	1.9E-03	4.9E-03	1.2E-05	2.0E-03	1.2E-05	5.3E-03	1.7E-01	1.8E-04	1.6E-04	1.2E-01	2.1E-03
>8-10 Aliphatics	5.9E-02	4.3E-02	4.3E-02	4.1E-02	4.1E-05	4.3E-02	4.1E-05	4.4E-03	2.9E-01	2.5E-04	1.3E-04	9.7E-02	3.0E-03
>10-12 Aliphatics	1.7E-01	1.2E-01	1.2E-01	1.1E-01	5.7E-05	1.2E-01	5.7E-05	1.2E-03	7.8E-02	4.4E-05	3.5E-05	2.6E-02	5.4E-04
>12-16 Aliphatics	2.8E-01	2.0E-01	2.0E-01	2.0E-01	3.5E-05	2.1E-01	3.5E-05	1.6E-04	1.0E-02	1.4E-06	4.7E-06	3.5E-03	1.6E-05
>16-21 Aliphatics	5.9E-02	2.1E-03	2.1E-03	0.0E+00	0.0E+00	2.0E-03	0.0E+00	0.0E+00	0.0E+00	3.5E-11	0.0E+00	0.0E+00	4.2E-10
>5-7 Aromatics	3.0E-04	2.2E-02	2.2E-02	2.3E-02	4.5E-04	2.2E-02	4.5E-04	4.3E-02	1.7E-01	8.8E-01	2.1E-03	1.3E+00	8.3E-02
>7-8 Aromatics	1.4E-04	5.2E-05	5.2E-05	2.5E-04	3.2E-06	6.2E-05	3.2E-06	1.3E-04	8.2E-04	5.1E-04	5.9E-06	3.8E-03	2.0E-04
>8-10 Aromatics	5.9E-02	1.1E-01	1.1E-01	2.1E-01	1.6E-03	1.1E-01	1.6E-03	2.1E-02	2.1E-01	1.0E-01	8.3E-04	5.6E-01	4.1E-01
>10-12 Aromatics	5.9E-02	1.1E-01	1.1E-01	2.1E-01	9.2E-04	1.1E-01	9.2E-04	2.2E-03	3.9E-02	3.6E-02	1.3E-04	7.3E-02	4.1E-01
>12-16 Aromatics	5.9E-02	1.1E-01	1.1E-01	2.1E-01	2.8E-04	1.1E-01	2.8E-04	1.7E-04	7.3E-03	7.2E-03	1.6E-05	7.0E-03	8.8E-02
>16-21 Aromatics	5.9E-02	1.4E-01	1.4E-01	0.0E+00	0.0E+00	1.4E-01	0.0E+00	0.0E+00	0.0E+00	8.5E-04	0.0E+00	0.0E+00	1.0E-02
>21-35 Aromatics	5.9E-02	1.4E-01	1.4E-01	0.0E+00	0.0E+00	1.4E-01	0.0E+00	0.0E+00	0.0E+00	6.9E-06	0.0E+00	0.0E+00	8.3E-05
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	3.5E-03	1.0E+00	3.5E-03	7.9E-02	1.0E+00	1.0E+00	3.4E-03	2.2E+00	1.0E+00
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.48E+05	9.34E+03	4.41E+11	7.08E+07	8.37E+03	7.08E+07	3.93E+05	1.96E+02	3.40E+03	1.76E+07	8.71E+03	2.80E+01
RBSL(C_{TPH}) (ng/kg)		100000	9000	4.E+11	$>C_{sat}$	8000	$>C_{sat}$	$>C_{sat}$	200	3000	>S	9000	30

Target Risk Level(HI) 1
Use Raoult's Law(Yes/No? yes

Pathways:
surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater
subsurface soil leaching to gw ingestion = ingestion of groundwater that contains contaminants leaching from subsurface soil

Table A-20: TPH Composition Data using TPHCWG Direct Method for Sample IRP4B15S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): IRP4B15S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.123	0.0615	3.52E-02	4.51E-04	6.23E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	1.60E-01	7.03E-04	9.70E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.67	0.335	1.92E-01	7.61E-04	1.05E-01
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	1.60E-01	6.36E-04	8.78E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	1.60E-01	6.36E-04	8.78E-02
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	1.60E-01	7.03E-04	9.70E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	1.60E-01	5.76E-04	7.96E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	1.60E-01	5.81E-04	8.01E-02
	TPH fractions							
	C>5-C6 aliphatics	8.10E+01		4.6	4.6	2.63E+00	3.25E-02	4.49E+00
	C>6-C8 aliphatics	1.00E+02		50	50	2.86E+01	2.86E-01	3.95E+01
	C>8-C10 aliphatics	1.30E+02	<	22	11	6.29E+00	4.84E-02	6.68E+00
	C>10-C12 aliphatics	1.60E+02	<	22	11	6.29E+00	3.93E-02	5.43E+00
	C>12-C16 aliphatics	2.00E+02		32	32	1.83E+01	9.16E-02	1.26E+01
	C >16-C21aliphatics	2.70E+02	<	22	11	6.29E+00	2.33E-02	3.22E+00
	C>5-C7 aromatics	7.80E+01		0.093	0.093	5.32E-02	6.82E-04	9.42E-02
	C>7-C8 aromatics	9.21E+01		0.056	0.056	3.20E-02	3.48E-04	4.80E-02
	C >8 - C10 aromatics	1.20E+02	<	22	11	6.29E+00	5.25E-02	7.24E+00
	C>10-C12 aromatics	1.30E+02	<	22	11	6.29E+00	4.84E-02	6.68E+00
	C>12-C16 aromatics	1.50E+02	<	22	11	6.29E+00	4.20E-02	5.79E+00
	C>16-C21 aromatics	1.90E+02	<	22	11	6.29E+00	3.31E-02	4.57E+00
	C>21-C35 aromatics	2.40E+02	<	22	11	6.29E+00	2.62E-02	3.62E+00

Total TPH fractions		*Sum of weight %*	7.24E-01
aliphatics	119.6	100	
aromatics	55.149		
Total	174.749		

Table A-21: TPH Fraction RBSLs using TPHCWG Direct Method for Sample IRP4B15S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
>5-6 Aliphatics	4.7E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	4.1E+03	6.1E+01	8.1E+04	1.0E+04	1.4E+01	5.1E+02
>6-8 Aliphatics	2.6E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	9.8E+03	1.5E+02	2.9E+05	6.8E+03	9.3E+00	5.1E+02
>8-10 Aliphatics	1.4E+02	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	2.3E+03	3.4E+01	4.1E+04	2.3E+02	3.2E-01	1.0E+01
>10-12 Aliphatics	8.6E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	1.2E+04	1.8E+02	3.1E+05	1.5E+02	2.1E-01	1.0E+01
>12-16 Aliphatics	3.8E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	5.4E+04	8.1E+02	6.2E+06	3.6E+01	4.9E-02	1.0E+01
>16-21 Aliphatics	1.6E+01	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	1.6E+10	No RfC	No RfC	2.0E+02
>5-7 Aromatics	1.6E+03	2.0E+03	1.3E+02	5.7E+09	2.2E+03	1.2E+02	2.2E+03	2.3E+01	3.5E-01	1.1E+00	5.2E+02	8.4E-01	1.0E-01
>7-8 Aromatics	1.3E+03	4.1E+05	2.6E+04	2.5E+11	9.7E+04	1.9E+04	9.7E+04	2.3E+03	3.4E+01	6.1E+02	2.1E+04	3.3E+01	2.0E+01
>8-10 Aromatics	1.0E+03	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	3.7E+03	5.6E+01	7.9E+02	6.1E+03	8.9E+00	4.1E+00
>10-12 Aromatics	6.3E+02	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	2.0E+04	3.0E+02	1.2E+03	1.4E+04	2.4E+01	4.1E+00
>12-16 Aromatics	2.9E+02	8.2E+04	5.2E+03	1.3E+11	6.4E+04	4.5E+03	6.4E+04	1.1E+05	1.6E+03	2.5E+03	2.3E+04	5.1E+01	4.1E+00
>16-21 Aromatics	1.0E+02	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	5.9E+03	No RfC	No RfC	3.1E+00
>21-35 Aromatics	8.3E+00	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	4.7E+04	No RfC	No RfC	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
>5-6 Aliphatics	2.6E-02	4.2E-04	4.2E-04	1.1E-03	4.7E-06	4.5E-04	4.7E-06	5.2E-03	5.9E-02	2.6E-04	1.6E-04	1.2E-01	1.3E-03
>6-8 Aliphatics	2.9E-01	4.5E-03	4.5E-03	1.2E-02	2.3E-05	4.9E-03	2.3E-05	1.0E-02	2.7E-01	3.4E-04	3.1E-04	2.3E-01	4.2E-03
>8-10 Aliphatics	6.3E-02	5.0E-02	5.0E-02	4.7E-02	3.9E-05	5.0E-02	3.9E-05	4.1E-03	2.5E-01	2.3E-04	1.2E-04	9.1E-02	2.8E-03
>10-12 Aliphatics	6.3E-02	5.0E-02	5.0E-02	4.7E-02	1.9E-05	5.0E-02	1.9E-05	3.9E-04	2.6E-02	1.5E-05	1.2E-05	8.8E-03	1.8E-04
>12-16 Aliphatics	1.8E-01	1.4E-01	1.4E-01	1.4E-01	2.0E-05	1.4E-01	2.0E-05	8.9E-05	6.0E-03	7.8E-07	2.7E-06	2.0E-03	9.4E-06
>16-21 Aliphatics	6.3E-02	2.5E-03	2.5E-03	0.0E+00	0.0E+00	2.4E-03	0.0E+00	0.0E+00	0.0E+00	3.2E-11	0.0E+00	0.0E+00	3.9E-10
>5-7 Aromatics	5.3E-04	4.2E-02	4.2E-02	4.4E-02	7.0E-04	4.2E-02	7.0E-04	6.6E-02	2.1E-01	1.4E+00	3.2E-03	2.0E+00	1.3E-01
>7-8 Aromatics	3.2E-04	1.3E-04	1.3E-04	6.0E-04	6.2E-06	1.5E-04	6.2E-06	2.6E-04	1.3E-03	1.0E-03	1.2E-05	7.5E-03	3.9E-04
>8-10 Aromatics	6.3E-02	1.2E-01	1.2E-01	2.4E-01	1.5E-03	1.3E-01	1.5E-03	2.0E-02	1.5E-01	9.5E-02	7.8E-04	5.3E-01	3.8E-01
>10-12 Aromatics	6.3E-02	1.2E-01	1.2E-01	2.4E-01	8.6E-04	1.3E-01	8.6E-04	2.1E-03	2.8E-02	3.4E-02	1.2E-04	6.9E-02	3.8E-01
>12-16 Aromatics	6.3E-02	1.2E-01	1.2E-01	2.4E-01	2.6E-04	1.3E-01	2.6E-04	1.6E-04	5.4E-03	6.8E-03	1.5E-05	6.6E-03	8.2E-02
>16-21 Aromatics	6.3E-02	1.7E-01	1.7E-01	0.0E+00	0.0E+00	1.6E-01	0.0E+00	0.0E+00	0.0E+00	8.0E-04	0.0E+00	0.0E+00	9.7E-03
>21-35 Aromatics	6.3E-02	1.7E-01	1.7E-01	0.0E+00	0.0E+00	1.6E-01	0.0E+00	0.0E+00	0.0E+00	6.4E-06	0.0E+00	0.0E+00	7.8E-05
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	3.5E-03	1.0E+00	3.5E-03	1.1E-01	1.0E+00	1.5E+00	4.8E-03	3.1E+00	1.0E+00
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.62E+05	1.02E+04	4.77E+11	7.08E+07	9.17E+03	7.08E+07	3.93E+05	1.36E+02	3.40E+03	1.76E+07	8.71E+03	2.50E+01
RBSL(C_{TPH}) (mg/kg)		200000	10000	5.E+11	>C_{sat}	9000	>C_{sat}	>C_{sat}	100	3000	>S	9000	20

Target Risk Level(HI) 1
Use Raoult's Law(Yes/No? yes
Pathways:

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater
subsurface soil leaching to gw ingestion = ingestion of groundwater that contains contaminants leaching from subsurface soil

Table A-22: TPH Composition Data using TPHCWG Direct Method for Sample IRP4B16S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): IRP4B16S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.127	0.0635	6.39E-02	8.19E-04	1.34E-01
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	2.82E-01	1.24E-03	2.02E-01
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.67	0.335	3.37E-01	1.34E-03	2.19E-01
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	2.82E-01	1.12E-03	1.83E-01
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	2.82E-01	1.12E-03	1.83E-01
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	2.82E-01	1.24E-03	2.02E-01
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	2.82E-01	1.01E-03	1.66E-01
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	2.82E-01	1.02E-03	1.67E-01
	TPH fractions							
	C>5-C6 aliphatics	8.10E+01		0.25	0.25	2.52E-01	3.11E-03	5.09E-01
	C>6-C8 aliphatics	1.00E+02	<	0.22	0.11	1.11E-01	1.11E-03	1.81E-01
	C>8-C10 aliphatics	1.30E+02	<	22	11	1.11E+01	8.52E-02	1.39E+01
	C>10-C12 aliphatics	1.60E+02	<	22	11	1.11E+01	6.92E-02	1.13E+01
	C>12-C16 aliphatics	2.00E+02	<	22	11	1.11E+01	5.54E-02	9.07E+00
	C >16-C21aliphatics	2.70E+02	<	22	11	1.11E+01	4.10E-02	6.72E+00
	C>5-C7 aromatics	7.80E+01	<	0.0056	0.0028	2.82E-03	3.61E-05	5.92E-03
	C>7-C8 aromatics	9.21E+01	<	0.0056	0.0028	2.82E-03	3.06E-05	5.01E-03
	C >8 - C10 aromatics	1.20E+02	<	22	11	1.11E+01	9.23E-02	1.51E+01
	C>10-C12 aromatics	1.30E+02	<	22	11	1.11E+01	8.52E-02	1.39E+01
	C>12-C16 aromatics	1.50E+02	<	22	11	1.11E+01	7.38E-02	1.21E+01
	C>16-C21 aromatics	1.90E+02	<	22	11	1.11E+01	5.83E-02	9.54E+00
	C>21-C35 aromatics	2.40E+02	<	22	11	1.11E+01	4.61E-02	7.55E+00

Total TPH fractions		*Sum of weight %*	6.11E-01
aliphatics	44.36	100	
aromatics	55.0056		
Total	99.3656		

Table A-23: TPH Fraction RBSLs using TPHCWG Direct Method for Sample IRP4B16S5-6P

	$C_{i,sat}$ TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
>5-6 Aliphatics	4.7E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	4.1E+03	6.1E+01	8.1E+04	1.0E+04	1.4E+01	5.1E+02
>6-8 Aliphatics	2.6E+02	1.0E+07	6.5E+05	1.2E+13	4.5E+06	5.4E+05	4.5E+06	9.8E+03	1.5E+02	2.9E+05	6.8E+03	9.3E+00	5.1E+02
>8-10 Aliphatics	1.4E+02	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	2.3E+03	3.4E+01	4.1E+04	2.3E+02	3.2E-01	1.0E+01
>10-12 Aliphatics	8.6E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	1.2E+04	1.8E+02	3.1E+05	1.5E+02	2.1E-01	1.0E+01
>12-16 Aliphatics	3.8E+01	2.0E+05	1.3E+04	6.3E+11	2.4E+05	1.2E+04	2.4E+05	5.4E+04	8.1E+02	6.2E+06	3.6E+01	4.9E-02	1.0E+01
>16-21 Aliphatics	1.6E+01	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	1.6E+10	No RfC	No RfC	2.0E+02
>5-7 Aromatics	1.6E+03	2.0E+03	1.3E+02	5.7E+09	2.2E+03	1.2E+02	2.2E+03	2.3E+01	3.5E-01	1.1E+00	5.2E+02	8.4E-01	1.0E-01
>7-8 Aromatics	1.3E+03	4.1E+05	2.6E+04	2.5E+11	9.7E+04	1.9E+04	9.7E+04	2.3E+03	3.4E+01	6.1E+02	2.1E+04	3.3E+01	2.0E+01
>8-10 Aromatics	1.0E+03	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	3.7E+03	5.6E+01	7.9E+02	6.1E+03	8.9E+00	4.1E+00
>10-12 Aromatics	6.3E+02	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	2.0E+04	3.0E+02	1.2E+03	1.4E+04	2.4E+01	4.1E+00
>12-16 Aromatics	2.9E+02	8.2E+04	5.2E+03	1.3E+11	6.4E+04	4.5E+03	6.4E+04	1.1E+05	1.6E+03	2.5E+03	2.3E+04	5.1E+01	4.1E+00
>16-21 Aromatics	1.0E+02	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	5.9E+03	No RfC	No RfC	3.1E+00
>21-35 Aromatics	8.3E+00	6.1E+04	3.9E+03	No RfC	No RfC	3.7E+03	No RfC	No RfC	No RfC	4.7E+04	No RfC	No RfC	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
>5-6 Aliphatics	2.5E-03	2.6E-05	2.6E-05	6.9E-05	5.3E-07	2.9E-05	5.3E-07	5.9E-04	6.7E-03	3.0E-05	1.8E-05	1.3E-02	7.3E-05
>6-8 Aliphatics	1.1E-03	1.2E-05	1.2E-05	3.0E-05	1.0E-07	1.3E-05	1.0E-07	4.7E-05	1.2E-03	1.6E-06	1.4E-06	1.1E-03	1.9E-05
>8-10 Aliphatics	1.1E-01	5.8E-02	5.8E-02	5.5E-02	8.1E-05	5.8E-02	8.1E-05	8.5E-03	5.2E-01	4.8E-04	2.6E-04	1.9E-01	5.9E-03
>10-12 Aliphatics	1.1E-01	5.8E-02	5.8E-02	5.5E-02	4.0E-05	5.8E-02	4.0E-05	8.2E-04	5.5E-02	3.1E-05	2.5E-05	1.8E-02	3.8E-04
>12-16 Aliphatics	1.1E-01	5.8E-02	5.8E-02	5.5E-02	1.4E-05	5.8E-02	1.4E-05	6.4E-05	4.3E-03	5.6E-07	1.9E-06	1.4E-03	6.7E-06
>16-21 Aliphatics	1.1E-01	2.9E-03	2.9E-03	0.0E+00	0.0E+00	2.8E-03	0.0E+00	0.0E+00	0.0E+00	6.8E-11	0.0E+00	0.0E+00	8.2E-10
>5-7 Aromatics	2.8E-05	1.5E-03	1.5E-03	1.6E-03	4.4E-05	1.5E-03	4.4E-05	4.1E-03	1.3E-02	8.5E-02	2.0E-04	1.3E-01	4.1E-03
>7-8 Aromatics	2.8E-05	7.4E-06	7.4E-06	3.5E-05	6.5E-07	8.8E-06	6.5E-07	2.7E-05	1.3E-04	1.0E-04	1.2E-06	7.8E-04	2.0E-05
>8-10 Aromatics	1.1E-01	1.4E-01	1.4E-01	2.8E-01	3.2E-03	1.5E-01	3.2E-03	4.2E-02	3.2E-01	2.0E-01	1.6E-03	1.1E+00	4.0E-01
>10-12 Aromatics	1.1E-01	1.4E-01	1.4E-01	2.8E-01	1.8E-03	1.5E-01	1.8E-03	4.3E-03	6.0E-02	7.0E-02	2.5E-04	1.4E-01	4.0E-01
>12-16 Aromatics	1.1E-01	1.4E-01	1.4E-01	2.8E-01	5.5E-04	1.5E-01	5.5E-04	3.3E-04	1.1E-02	1.4E-02	3.1E-05	1.4E-02	1.7E-01
>16-21 Aromatics	1.1E-01	1.9E-01	1.9E-01	0.0E+00	0.0E+00	1.8E-01	0.0E+00	0.0E+00	0.0E+00	1.7E-03	0.0E+00	0.0E+00	2.0E-02
>21-35 Aromatics	1.1E-01	1.9E-01	1.9E-01	0.0E+00	0.0E+00	1.8E-01	0.0E+00	0.0E+00	0.0E+00	1.3E-05	0.0E+00	0.0E+00	1.6E-04
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	5.8E-03	1.0E+00	5.8E-03	6.1E-02	1.0E+00	3.7E-01	2.4E-03	1.6E+00	1.0E+00
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.07E+05	6.78E+03	3.18E+11	7.08E+07	6.08E+03	7.08E+07	3.93E+05	1.63E+02	3.66E+03	1.76E+07	8.71E+03	1.47E+01
RBSL(C_{TPH}) (mg/kg)		100000	7000	3.E+11	>C_{sat}	6000	>C_{sat}	>C_{sat}	200	>C_{sat}	>S	9000	10

Target Risk Level(HI) 1
Use Raoult's Law(Yes/No? yes
Pathways:
surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater
subsurface soil leaching to gw ingestion = ingestion of groundwater that contains contaminants leaching from subsurface soil

Table A-24: TPH Composition Data using MA DEP Protocols for Sample IRP4B01S4-5P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): RP4B01S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.113	0.0565	9.54E-02	1.22E-03	1.91E-01
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.55	0.275	4.65E-01	2.04E-03	3.17E-01
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.66	0.33	5.57E-01	2.21E-03	3.45E-01
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.55	0.275	4.65E-01	1.84E-03	2.87E-01
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.55	0.275	4.65E-01	1.84E-03	2.87E-01
218-01-9	Chrysene	2.28E+02	<	0.55	0.275	4.65E-01	2.04E-03	3.17E-01
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.55	0.275	4.65E-01	1.67E-03	2.60E-01
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.55	0.275	4.65E-01	1.68E-03	2.62E-01
	TPH fractions							
	C5-C8 aliphatics	9.30E+01		8.7	8.7	1.47E+01	1.58E-01	2.46E+01
	C9-C18 aliphatics	1.70E+02		32.3	32.3	5.46E+01	3.21E-01	5.00E+01
	C19-C36 aliphatics	3.50E+02	<	13	6.5	1.10E+01	3.14E-02	4.89E+00
	C9-C22 aromatics	1.50E+02		11.7	11.7	1.98E+01	1.32E-01	2.05E+01

Total TPH fractions		*Sum of weight %*	6.42E-01
aliphatics	47.5	100	
aromatics	11.7		
Total	59.2		

Table A-25: TPH Fraction RBSLs using MA DEP Protocols for Sample IRP4B01S4-5P

	C_{sat}	Surface Soil	Surface Soil	Fugitive Dust	Surface soil	Surface soil	Surface soil	Subsurface soil	Subsurface soil	Subsurface soil	Groundwater	Groundwater	Groundwater
	TPH fractions (i)	Ingestion	Dermal	Inhalation	Outdoor vapor Inhalation	Soil, Dust, Vapor Combined	Indoor vapor Inhalation	Outdoor vapor Inhalation	Indoor vapor Inhalation	Leaching to gw Ingestion	Outdoor vapor Inhalation	Indoor vapor Inhalation	Ingestion
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
C5-C8 Aliphatics	3.4E+01	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	8.1E+01	1.2E+00	1.5E+03	8.6E+01	1.2E-01	4.1E+00
C9-C18 Aliphatics	6.8E+01	2.0E+05	1.3E+04	1.3E+11	4.9E+04	9.7E+03	4.9E+04	1.6E+04	1.6E+04	8.4E+05	7.7E+01	1.0E-01	1.0E+01
C19-C36 Aliphatics	1.5E-03	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	3.8E+06	No RfC	No RfC	2.0E+02
C9-C22 Aromatics	2.9E+02	6.1E+04	3.9E+03	3.2E+10	2.7E+04	3.2E+03	2.7E+04	7.8E+04	1.2E+03	1.9E+03	9.6E+03	3.1E+01	3.1E+00
	Weight Fraction (f_i)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
	(mg/kg/mg/kg)												
C5-C8 Aliphatics	1.5E-01	2.3E-01	2.3E-01	9.9E-02	1.7E-04	2.2E-01	1.7E-04	1.0E-01	1.0E+00	5.5E-03	3.2E-03	9.5E-01	6.6E-02
C9-C18 Aliphatics	5.5E-01	3.5E-01	3.5E-01	3.7E-01	7.0E-04	3.7E-01	7.0E-04	2.2E-03	2.8E-04	4.0E-05	6.5E-05	4.8E-02	4.9E-04
C19-C36 Aliphatics	1.1E-01	3.5E-03	3.5E-03	0.0E+00	0.0E+00	3.0E-03	0.0E+00	0.0E+00	0.0E+00	2.0E-11	0.0E+00	0.0E+00	2.4E-10
C9-C22 Aromatics	2.0E-01	4.2E-01	4.2E-01	5.3E-01	2.2E-03	4.1E-01	2.2E-03	7.6E-04	1.4E-03	3.2E-02	1.2E-04	4.8E-03	3.9E-01
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	3.1E-03	1.0E+00	3.1E-03	1.1E-01	1.0E+00	3.8E-02	3.3E-03	1.0E+00	4.5E-01
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.30E+05	8.20E+03	8.56E+10	2.19E+06	6.62E+03	2.19E+06	2.16E+04	8.17E+00	1.77E+03	5.30E+05	7.51E-01	6.67E+00
RBSL(C_{TPH}) (mg/kg)		100000	8000	9E+10	>Csat	7000	>Csat	>Csat	8	>Csat	>S	0.8	>S

Target Risk Level (HI) 1

Use Raout's Law (Yes/No?) yes

Pathways

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater

Table A-26: TPH Composition Data using MA DEP Protocols for Sample IRP4B02S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): RP4B02S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.111	0.0555	3.15E-02	4.04E-04	6.04E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	1.59E-01	6.97E-04	1.04E-01
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.67	0.335	1.90E-01	7.54E-04	1.13E-01
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	1.59E-01	6.31E-04	9.44E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	1.59E-01	6.31E-04	9.44E-02
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	1.59E-01	6.97E-04	1.04E-01
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	1.59E-01	5.72E-04	8.55E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	1.59E-01	5.76E-04	8.61E-02
	TPH fractions							
	C5-C8 aliphatics	9.30E+01		26.9	26.9	1.53E+01	1.64E-01	2.46E+01
	C9-C18 aliphatics	1.70E+02		104.8	104.8	5.95E+01	3.50E-01	5.23E+01
	C19-C36 aliphatics	3.50E+02	<	13	6.5	3.69E+00	1.05E-02	1.58E+00
	C9-C22 aromatics	1.50E+02		38	38	2.16E+01	1.44E-01	2.15E+01

Total TPH fractions		*Sum of weight %*	6.68E-01
aliphatics	138.2	100	
aromatics	38		
Total	176.2		

Table A-27: TPH Fraction RBSLs using MA DEP Protocols for Sample IRP4B02S5-6P

	C_{sat}	Surface Soil	Surface Soil	Fugitive Dust	Surface soil Outdoor vapor	Surface soil Soil, Dust, Vapor	Surface soil Indoor vapor	Subsurface soil Outdoor vapor	Subsurface soil Indoor vapor	Subsurface soil Leaching to gw	Groundwater Outdoor vapor	Groundwater Indoor vapor	Groundwater
	TPH fractions (i)	Ingestion	Dermal	Inhalation	Inhalation	Combined	Inhalation	Inhalation	Inhalation	Ingestion	Inhalation	Inhalation	Ingestion
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
C5C8 Aliphatics	3.4E+01	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	8.1E+01	1.2E+00	1.5E+03	8.6E+01	1.2E-01	4.1E+00
C9C18 Aliphatics	6.8E+01	2.0E+05	1.3E+04	1.3E+11	4.9E+04	9.7E+03	4.9E+04	1.6E+04	1.6E+04	8.4E+05	7.7E+01	1.0E-01	1.0E+01
C19C36 Aliphatics	1.5E-03	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	3.8E+06	No RfC	No RfC	2.0E+02
C9-C22 Aromatics	2.9E+02	6.1E+04	3.9E+03	3.2E+10	2.7E+04	3.2E+03	2.7E+04	7.8E+04	1.2E+03	1.9E+03	9.6E+03	3.1E+01	3.1E+00
	Weight Fraction (f_i)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
	(mg/kg/mg/kg)												
C5C8 Aliphatics	1.5E-01	2.2E-01	2.2E-01	9.5E-02	1.7E-04	2.1E-01	1.7E-04	1.0E-01	1.0E+00	5.5E-03	3.1E-03	9.4E-01	6.6E-02
C9C18 Aliphatics	5.9E-01	3.5E-01	3.5E-01	3.7E-01	7.3E-04	3.8E-01	7.3E-04	2.3E-03	3.0E-04	4.2E-05	6.8E-05	5.0E-02	5.1E-04
C19C36 Aliphatics	3.7E-02	1.1E-03	1.1E-03	0.0E+00	0.0E+00	9.3E-04	0.0E+00	0.0E+00	0.0E+00	6.4E-12	0.0E+00	0.0E+00	7.7E-11
C9-C22 Aromatics	2.2E-01	4.2E-01	4.2E-01	5.4E-01	2.3E-03	4.1E-01	2.3E-03	8.0E-04	1.5E-03	3.4E-02	1.3E-04	5.0E-03	4.1E-01
Total	1.0E+00												
Hazard Index (HI) (ΣHQ)		1.0E+00	1.0E+00	1.0E+00	3.2E-03	1.0E+00	3.2E-03	1.1E-01	1.0E+00	3.9E-02	3.3E-03	1.0E+00	4.7E-01
		TPH Risk Based Screening Levels											
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)	
Tota TPH (mg/kg)	1.20E+05	7.62E+03	7.88E+10	2.19E+06	6.15E+03	2.19E+06	2.16E+04	7.86E+00	1.77E+03	5.30E+05	7.21E-01	6.67E+00	
RBSl(C_{TPH}) (mg/kg)	100000	8000	8E+10	>Csat	6000	>Csat	>Csat	8	>Csat	>S	0.7	>S	

Target Risk Level (HI) 1

Use Raoult's Law (Yes/No?) yes

Pathways

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater

Table A-28: TPH Composition Data using MA DEP Protocols for Sample IRP4B03S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SAN GB POL Area
(LOCATION): RP4B03S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.126	0.063	1.13E-02	1.45E-04	2.06E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.55	0.275	4.95E-02	2.17E-04	3.08E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.66	0.33	5.94E-02	2.36E-04	3.34E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.55	0.275	4.95E-02	1.96E-04	2.79E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.55	0.275	4.95E-02	1.96E-04	2.79E-02
218-01-9	Chrysene	2.28E+02	<	0.55	0.275	4.95E-02	2.17E-04	3.08E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.55	0.275	4.95E-02	1.78E-04	2.53E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.55	0.275	4.95E-02	1.79E-04	2.54E-02
	TPH fractions							
	C5-C8 aliphatics	9.30E+01		116	116	2.09E+01	2.25E-01	3.19E+01
	C9-C18 aliphatics	1.70E+02		302	302	5.44E+01	3.20E-01	4.54E+01
	C19-C36 aliphatics	3.50E+02	<	13	6.5	1.17E+00	3.34E-03	4.74E-01
	C9-C22 aromatics	1.50E+02		131	131	2.36E+01	1.57E-01	2.23E+01

Total TPH fractions		*Sum of weight %*	7.05E-01
aliphatics	424.5	100	
aromatics	131		
Total	555.5		

Table A-29: TPH Fraction RBSLs using MA DEP Protocols for Sample IRP4B03S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
C5-C8 Aliphatics	3.4E+01	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	8.1E+01	1.2E+00	1.5E+03	8.6E+01	1.2E-01	4.1E+00
C9-C18 Aliphatics	6.8E+01	2.0E+05	1.3E+04	1.3E+11	4.9E+04	9.7E+03	4.9E+04	1.6E+04	1.6E+04	8.4E+05	7.7E+01	1.0E-01	1.0E+01
C19-C36 Aliphatics	1.5E-03	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	3.8E+06	No RfC	No RfC	2.0E+02
C9-C22 Aromatics	2.9E+02	6.1E+04	3.9E+03	3.2E+10	2.7E+04	3.2E+03	2.7E+04	7.8E+04	1.2E+03	1.9E+03	9.6E+03	3.1E+01	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
C5-C8 Aliphatics	2.1E-01	2.8E-01	2.8E-01	1.2E-01	2.2E-04	2.7E-01	2.2E-04	1.3E-01	1.0E+00	7.1E-03	4.1E-03	9.5E-01	8.6E-02
C9-C18 Aliphatics	5.4E-01	2.9E-01	2.9E-01	3.2E-01	6.3E-04	3.2E-01	6.3E-04	2.0E-03	2.0E-04	3.7E-05	5.9E-05	4.3E-02	4.4E-04
C19-C36 Aliphatics	1.2E-02	3.2E-04	3.2E-04	0.0E+00	0.0E+00	2.7E-04	0.0E+00	0.0E+00	0.0E+00	1.9E-12	0.0E+00	0.0E+00	2.3E-11
C9-C22 Aromatics	2.4E-01	4.2E-01	4.2E-01	5.6E-01	2.4E-03	4.2E-01	2.4E-03	8.3E-04	1.2E-03	3.5E-02	1.3E-04	4.1E-03	4.2E-01
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	3.2E-03	1.0E+00	3.2E-03	1.4E-01	1.0E+00	4.2E-02	4.3E-03	1.0E+00	5.1E-01
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
TotalTPH (mg/kg)		1.10E+05	6.98E+03	7.49E+10	2.19E+06	5.67E+03	2.19E+06	2.16E+04	5.75E+00	1.77E+03	5.30E+05	5.32E-01	6.67E+00
$RBSL_{C_{TPH}}$ (mg/kg)		100000	7000	7E+10	>Csat	6000	>Csat	>Csat	6	>Csat	>S	0.5	>S

Target Risk Level (HI) 1

Use Raout's Law (Yes/No?) yes

Pathways

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater

Table A-30: TPH Composition Data using MA DEP Protocols for Sample IRP4B04S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): RP4B04S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.137	0.0685	6.76E-02	8.67E-04	1.26E-01
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	2.76E-01	1.21E-03	1.76E-01
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.67	0.335	3.31E-01	1.31E-03	1.90E-01
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	2.76E-01	1.10E-03	1.59E-01
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	2.76E-01	1.10E-03	1.59E-01
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	2.76E-01	1.21E-03	1.76E-01
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	2.76E-01	9.94E-04	1.44E-01
193-39-5	hdeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	2.76E-01	1.00E-03	1.45E-01
	TPH fractions							
	C5-C8 aliphatics	9.30E+01		21.5	21.5	2.12E+01	2.28E-01	3.31E+01
	C9-C18 aliphatics	1.70E+02		50.3	50.3	4.97E+01	2.92E-01	4.23E+01
	C19-C36 aliphatics	3.50E+02	<	13	6.5	6.42E+00	1.83E-02	2.66E+00
	C9-C22 aromatics	1.50E+02		23	23	2.27E+01	1.51E-01	2.19E+01

Total TPH fractions		*Sum of weight %*	6.90E-01
aliphatics	78.3	100	
aromatics	23		
Total	101.3		

Table A-31: TPH Fraction RBSLs using MA DEP Protocols for Sample IRP4B04S5-6P

	C_{ssat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
C5-C8 Aliphatics	3.4E+01	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	8.1E+01	1.2E+00	1.5E+03	8.6E+01	1.2E-01	4.1E+00
C9-C18 Aliphatics	6.8E+01	2.0E+05	1.3E+04	1.3E+11	4.9E+04	9.7E+03	4.9E+04	1.6E+04	1.6E+04	8.4E+05	7.7E+01	1.0E-01	1.0E+01
C19-C36 Aliphatics	1.5E-03	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	3.8E+06	No RfC	No RfC	2.0E+02
C9-C22 Aromatics	2.9E+02	6.1E+04	3.9E+03	3.2E+10	2.7E+04	3.2E+03	2.7E+04	7.8E+04	1.2E+03	1.9E+03	9.6E+03	3.1E+01	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
C5-C8 Aliphatics	2.1E-01	3.0E-01	3.0E-01	1.3E-01	2.3E-04	2.8E-01	2.3E-04	1.4E-01	1.0E+00	7.3E-03	4.2E-03	9.6E-01	8.9E-02
C9-C18 Aliphatics	5.0E-01	2.8E-01	2.8E-01	3.1E-01	5.9E-04	3.0E-01	5.9E-04	1.8E-03	1.8E-04	3.4E-05	5.5E-05	4.1E-02	4.1E-04
C19-C36 Aliphatics	6.4E-02	1.8E-03	1.8E-03	0.0E+00	0.0E+00	1.6E-03	0.0E+00	0.0E+00	0.0E+00	1.1E-11	0.0E+00	0.0E+00	1.3E-10
C9-C22 Aromatics	2.3E-01	4.2E-01	4.2E-01	5.6E-01	2.3E-03	4.2E-01	2.3E-03	8.2E-04	1.1E-03	3.4E-02	1.3E-04	3.9E-03	4.1E-01
Total	1.0E+00												
Hazard Index (HI) (ΣHQ)		1.0E+00	1.0E+00	1.0E+00	3.2E-03	1.0E+00	3.2E-03	1.4E-01	1.0E+00	4.2E-02	4.4E-03	1.0E+00	5.0E-01
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
TotalTPH (mg/kg)		1.14E+05	7.24E+03	7.85E+10	2.19E+06	5.89E+03	2.19E+06	2.16E+04	5.66E+00	1.77E+03	5.30E+05	5.25E-01	6.67E+00
RBSL(C_{TPH}) (mg/kg)		100000	7000	8E+10	>Csat	6000	>Csat	>Csat	6	>Csat	>S	0.5	>S

Target Risk Level (HI) 1

Use Raoult's Law (Yes/No?) yes

Pathways

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater

Table A-32: TPH Composition Data using MA DEP Protocols for Sample IRP4B08S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): RP4B08S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.136	0.068	9.32E-03	1.20E-04	1.72E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.55	0.275	3.77E-02	1.65E-04	2.37E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.66	0.33	4.52E-02	1.80E-04	2.58E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.55	0.275	3.77E-02	1.50E-04	2.15E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.55	0.275	3.77E-02	1.50E-04	2.15E-02
218-01-9	Chrysene	2.28E+02	<	0.55	0.275	3.77E-02	1.65E-04	2.37E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.55	0.275	3.77E-02	1.36E-04	1.95E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.55	0.275	3.77E-02	1.37E-04	1.96E-02
	TPH fractions							
	C5-C8 aliphatics	9.30E+01		142	142	1.95E+01	2.09E-01	3.00E+01
	C9-C18 aliphatics	1.70E+02		430	430	5.89E+01	3.47E-01	4.98E+01
	C19-C36 aliphatics	3.50E+02	<	13	6.5	8.91E-01	2.55E-03	3.65E-01
	C9-C22 aromatics	1.50E+02		151	151	2.07E+01	1.38E-01	1.98E+01

Total TPH fractions		*Sum of weight %*	6.97E-01
aliphatics	578.5	100	
aromatics	151		
Total	729.5		

Table A-33: TPH Fraction RBSLs using MA DEP Protocols for Sample IRP4B08S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
C5-C8 Aliphatics	3.4E+01	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	8.1E+01	1.2E+00	1.5E+03	8.6E+01	1.2E-01	4.1E+00
C9-C18 Aliphatics	6.8E+01	2.0E+05	1.3E+04	1.3E+11	4.9E+04	9.7E+03	4.9E+04	1.6E+04	1.6E+04	8.4E+05	7.7E+01	1.0E-01	1.0E+01
C19-C36 Aliphatics	1.5E-03	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	3.8E+06	No RfC	No RfC	2.0E+02
C9-C22 Aromatics	2.9E+02	6.1E+04	3.9E+03	3.2E+10	2.7E+04	3.2E+03	2.7E+04	7.8E+04	1.2E+03	1.9E+03	9.6E+03	3.1E+01	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
C5-C8 Aliphatics	1.9E-01	2.8E-01	2.8E-01	1.2E-01	2.1E-04	2.6E-01	2.1E-04	1.3E-01	1.0E+00	6.7E-03	3.8E-03	9.5E-01	8.1E-02
C9-C18 Aliphatics	5.9E-01	3.3E-01	3.3E-01	3.7E-01	7.0E-04	3.6E-01	7.0E-04	2.1E-03	2.3E-04	4.0E-05	6.5E-05	4.8E-02	4.9E-04
C19-C36 Aliphatics	8.9E-03	2.5E-04	2.5E-04	0.0E+00	0.0E+00	2.2E-04	0.0E+00	0.0E+00	0.0E+00	1.5E-12	0.0E+00	0.0E+00	1.8E-11
C9-C22 Aromatics	2.1E-01	3.9E-01	3.9E-01	5.1E-01	2.1E-03	3.8E-01	2.1E-03	7.4E-04	1.1E-03	3.1E-02	1.2E-04	3.8E-03	3.7E-01
Total	1.0E+00												
Hazard Index (HI) (ΣHQ)		1.0E+00	1.0E+00	1.0E+00	3.0E-03	1.0E+00	3.0E-03	1.3E-01	1.0E+00	3.8E-02	4.0E-03	1.0E+00	4.6E-01
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
TotalTPH (mg/kg)		1.16E+05	7.32E+03	7.88E+10	2.19E+06	5.92E+03	2.19E+06	2.16E+04	6.17E+00	1.77E+03	5.30E+05	5.68E-01	6.67E+00
$RBSL_{C_{TPH}}$ (mg/kg)		100000	7000	8E+10	>Csat	6000	>Csat	>Csat	6	>Csat	>S	0.6	>S

Target Risk Level (HI) 1

Use Raoul's Law (Yes/No?) yes

Pathways

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater

Table A-34: TPH Composition Data using MA DEP Protocols for Sample IRP4B09S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): RP4B09S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.125	0.0625	1.08E-02	1.38E-04	2.09E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.55	0.275	4.73E-02	2.08E-04	3.15E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.66	0.33	5.68E-02	2.25E-04	3.42E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.55	0.275	4.73E-02	1.88E-04	2.85E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.55	0.275	4.73E-02	1.88E-04	2.85E-02
218-01-9	Chrysene	2.28E+02	<	0.55	0.275	4.73E-02	2.08E-04	3.15E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.55	0.275	4.73E-02	1.70E-04	2.58E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.55	0.275	4.73E-02	1.71E-04	2.60E-02
	TPH fractions							
	C5-C8 aliphatics	9.30E+01		66.7	66.7	1.15E+01	1.23E-01	1.87E+01
	C9-C18 aliphatics	1.70E+02		376	376	6.47E+01	3.81E-01	5.78E+01
	C19-C36 aliphatics	3.50E+02	<	13	6.5	1.12E+00	3.20E-03	4.85E-01
	C9-C22 aromatics	1.50E+02		131.9	131.9	2.27E+01	1.51E-01	2.30E+01

Total TPH fractions		*Sum of weight %*	6.59E-01
aliphatics	449.2	100	
aromatics	131.9		
Total	581.1		

Table A-35: TPH Fraction RBSLs using MA DEP Protocols for Sample IRP4B09S5-6P

	C_{ksat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
C5-C8 Aliphatics	3.4E+01	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	8.1E+01	1.2E+00	1.5E+03	8.6E+01	1.2E-01	4.1E+00
C9-C18 Aliphatics	6.8E+01	2.0E+05	1.3E+04	1.3E+11	4.9E+04	9.7E+03	4.9E+04	1.6E+04	1.6E+04	8.4E+05	7.7E+01	1.0E-01	1.0E+01
C19-C36 Aliphatics	1.5E-03	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	3.8E+06	No RfC	No RfC	2.0E+02
C9-C22 Aromatics	2.9E+02	6.1E+04	3.9E+03	3.2E+10	2.7E+04	3.2E+03	2.7E+04	7.8E+04	1.2E+03	1.9E+03	9.6E+03	3.1E+01	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
C5-C8 Aliphatics	1.1E-01	1.7E-01	1.7E-01	6.9E-02	1.3E-04	1.6E-01	1.3E-04	7.9E-02	1.0E+00	4.2E-03	2.4E-03	9.4E-01	5.0E-02
C9-C18 Aliphatics	6.5E-01	3.8E-01	3.8E-01	3.9E-01	8.1E-04	4.1E-01	8.1E-04	2.5E-03	4.3E-04	4.7E-05	7.5E-05	5.5E-02	5.7E-04
C19-C36 Aliphatics	1.1E-02	3.3E-04	3.3E-04	0.0E+00	0.0E+00	2.8E-04	0.0E+00	0.0E+00	0.0E+00	2.0E-12	0.0E+00	0.0E+00	2.4E-11
C9-C22 Aromatics	2.3E-01	4.5E-01	4.5E-01	5.4E-01	2.4E-03	4.3E-01	2.4E-03	8.6E-04	2.0E-03	3.6E-02	1.4E-04	7.0E-03	4.3E-01
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	3.4E-03	1.0E+00	3.4E-03	8.3E-02	1.0E+00	4.0E-02	2.6E-03	1.0E+00	4.9E-01
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
TotalTPH (mg/kg)		1.21E+05	7.65E+03	7.60E+10	2.19E+06	6.14E+03	2.19E+06	2.16E+04	1.04E+01	1.77E+03	5.30E+05	9.52E-01	6.67E+00
RBSL(C_{TPH}) (mg/kg)		100000	8000	8E+10	>Csat	6000	>Csat	>Csat	10	>Csat	>S	1	>S

Target Risk Level (HI) 1

Use Raoult's Law (Yes/No?) yes

Pathways

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater

Table A-36: TPH Composition Data using MA DEP Protocols for Sample IRP4B10S5-6P

(MM/D/YR): (1/14/03
(TYPE): Soil
(SITE NAME: SANGB POL Area
(LOCATION) IRP4B10S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.125	0.0625	7.58E-03	9.72E-05	1.43E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	3.40E-02	1.49E-04	2.19E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.67	0.335	4.06E-02	1.61E-04	2.37E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	3.40E-02	1.35E-04	1.98E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	3.40E-02	1.35E-04	1.98E-02
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	3.40E-02	1.49E-04	2.19E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	3.40E-02	1.22E-04	1.80E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	3.40E-02	1.23E-04	1.81E-02
	TPH fractions							
	C5-C8 aliphatics	9.30E+01		132	132	1.60E+01	1.72E-01	2.53E+01
	C9-C18 aliphatics	1.70E+02		520	520	6.31E+01	3.71E-01	5.46E+01
	C19-C36 aliphatics	3.50E+02	<	13	6.5	7.88E-01	2.25E-03	3.31E-01
	C9-C22 aromatics	1.50E+02		166	166	2.01E+01	1.34E-01	1.97E+01

Total TPH fractions		*Sum of weight %*	6.80E-01
aliphatics	658.5	100	
aromatics	166		
Total	824.5		

Table A-37: TPH Fraction RBSLs using MA DEP Protocols for Sample IRP4B10S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
C5-C8 Aliphatics	3.4E+01	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	8.1E+01	1.2E+00	1.5E+03	8.6E+01	1.2E-01	4.1E+00
C9-C18 Aliphatics	6.8E+01	2.0E+05	1.3E+04	1.3E+11	4.9E+04	9.7E+03	4.9E+04	1.6E+04	1.6E+04	8.4E+05	7.7E+01	1.0E-01	1.0E+01
C19-C36 Aliphatics	1.5E-03	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	3.8E+06	No RfC	No RfC	2.0E+02
C9-C22 Aromatics	2.9E+02	6.1E+04	3.9E+03	3.2E+10	2.7E+04	3.2E+03	2.7E+04	7.8E+04	1.2E+03	1.9E+03	9.6E+03	3.1E+01	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
C5-C8 Aliphatics	1.6E-01	2.4E-01	2.4E-01	1.0E-01	1.8E-04	2.2E-01	1.8E-04	1.1E-01	1.0E+00	5.6E-03	3.2E-03	9.4E-01	6.8E-02
C9-C18 Aliphatics	6.3E-01	3.7E-01	3.7E-01	4.0E-01	7.6E-04	4.0E-01	7.6E-04	2.3E-03	3.0E-04	4.4E-05	7.1E-05	5.2E-02	5.3E-04
C19-C36 Aliphatics	7.9E-03	2.3E-04	2.3E-04	0.0E+00	0.0E+00	2.0E-04	0.0E+00	0.0E+00	0.0E+00	1.3E-12	0.0E+00	0.0E+00	1.6E-11
C9-C22 Aromatics	2.0E-01	3.9E-01	3.9E-01	5.0E-01	2.1E-03	3.8E-01	2.1E-03	7.4E-04	1.3E-03	3.1E-02	1.2E-04	4.5E-03	3.7E-01
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	3.0E-03	1.0E+00	3.0E-03	1.1E-01	1.0E+00	3.7E-02	3.4E-03	1.0E+00	4.4E-01
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
TotalTPH (mg/kg)		1.20E+05	7.60E+03	7.95E+10	2.19E+06	6.12E+03	2.19E+06	2.16E+04	7.50E+00	1.77E+03	5.30E+05	6.87E-01	6.67E+00
$RBSL_{C_{TPH}}$ (mg/kg)		100000	8000	8E+10	>Csat	6000	>Csat	>Csat	7	>Csat	>S	0.7	>S

Target Risk Level (HI) 1

Use Raoul's Law (Yes/No?) yes

Pathways

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater

Table A-38: TPH Composition Data using MA DEP Protocols for Sample IRP4B12S5-6P

(MM/D/YR): 07/14/03
(TYPE): Soil
(SITE NAME): SANGB POL Area
(LOCATION): RP4B12S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.12	0.06	1.04E-02	1.34E-04	1.96E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.57	0.285	4.95E-02	2.17E-04	3.19E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.68	0.34	5.90E-02	2.34E-04	3.44E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.57	0.285	4.95E-02	1.96E-04	2.88E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.57	0.285	4.95E-02	1.96E-04	2.88E-02
218-01-9	Chrysene	2.28E+02	<	0.57	0.285	4.95E-02	2.17E-04	3.19E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.57	0.285	4.95E-02	1.78E-04	2.61E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.57	0.285	4.95E-02	1.79E-04	2.63E-02
	TPH fractions							
	C5-C8 aliphatics	9.30E+01		94.3	94.3	1.64E+01	1.76E-01	2.58E+01
	C9-C18 aliphatics	1.70E+02		352	352	6.11E+01	3.60E-01	5.28E+01
	C19-C36 aliphatics	3.50E+02	<	13	6.5	1.13E+00	3.23E-03	4.73E-01
	C9-C22 aromatics	1.50E+02		123	123	2.14E+01	1.42E-01	2.09E+01

Total TPH fractions		*Sum of weight %*	6.81E-01
aliphatics	452.8	100	
aromatics	123		
Total	575.8		

Table A-39: TPH Fraction RBSLs using MA DEP Protocols for Sample IRP4B12S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
C5-C8 Aliphatics	3.4E+01	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	8.1E+01	1.2E+00	1.5E+03	8.6E+01	1.2E-01	4.1E+00
C9-C18 Aliphatics	6.8E+01	2.0E+05	1.3E+04	1.3E+11	4.9E+04	9.7E+03	4.9E+04	1.6E+04	1.6E+04	8.4E+05	7.7E+01	1.0E-01	1.0E+01
C19-C36 Aliphatics	1.5E-03	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	3.8E+06	No RfC	No RfC	2.0E+02
C9-C22 Aromatics	2.9E+02	6.1E+04	3.9E+03	3.2E+10	2.7E+04	3.2E+03	2.7E+04	7.8E+04	1.2E+03	1.9E+03	9.6E+03	3.1E+01	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
C5-C8 Aliphatics	1.6E-01	2.4E-01	2.4E-01	1.0E-01	1.8E-04	2.2E-01	1.8E-04	1.1E-01	1.0E+00	5.7E-03	3.3E-03	9.4E-01	7.0E-02
C9-C18 Aliphatics	6.1E-01	3.5E-01	3.5E-01	3.8E-01	7.4E-04	3.8E-01	7.4E-04	2.3E-03	2.8E-04	4.3E-05	6.9E-05	5.1E-02	5.2E-04
C19-C36 Aliphatics	1.1E-02	3.3E-04	3.3E-04	0.0E+00	0.0E+00	2.8E-04	0.0E+00	0.0E+00	0.0E+00	1.9E-12	0.0E+00	0.0E+00	2.3E-11
C9-C22 Aromatics	2.1E-01	4.1E-01	4.1E-01	5.2E-01	2.2E-03	4.0E-01	2.2E-03	7.8E-04	1.3E-03	3.3E-02	1.3E-04	4.7E-03	4.0E-01
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	3.1E-03	1.0E+00	3.1E-03	1.1E-01	1.0E+00	3.8E-02	3.5E-03	1.0E+00	4.7E-01
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
TotalTPH (mg/kg)		1.18E+05	7.46E+03	7.79E+10	2.19E+06	6.02E+03	2.19E+06	2.16E+04	7.33E+00	1.77E+03	5.30E+05	6.72E-01	6.67E+00
RBSL(C_{TPH}) (mg/kg)		100000	7000	8E+10	>Csat	6000	>Csat	>Csat	7	>Csat	>S	0.7	>S

Target Risk Level (HI) 1

Use Raoult's Law (Yes/No?) yes

Pathways

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater

Table A-40: TPH Composition Data using MA DEP Protocols for Sample IRP4B14S5-6P

(MM/D/YR): 07/14/03
(TYPE): Soil
(SITE NAME):SANGB POL Area
(LOCATION): RP4B14S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.137	0.0685	2.41E-02	3.09E-04	4.29E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	9.85E-02	4.32E-04	6.00E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.68	0.34	1.20E-01	4.74E-04	6.60E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	9.85E-02	3.91E-04	5.43E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	9.85E-02	3.91E-04	5.43E-02
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	9.85E-02	4.32E-04	6.00E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	9.85E-02	3.54E-04	4.92E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	9.85E-02	3.57E-04	4.96E-02
	TPH fractions							
	C5-C8 aliphatics	9.30E+01		70.8	70.8	2.49E+01	2.68E-01	3.72E+01
	C9-C18 aliphatics	1.70E+02		147	147	5.17E+01	3.04E-01	4.23E+01
	C19-C36 aliphatics	3.50E+02	<	13	6.5	2.29E+00	6.53E-03	9.08E-01
	C9-C22 aromatics	1.50E+02		60.1	60.1	2.11E+01	1.41E-01	1.96E+01

Total TPH fractions		*Sum of weight %*	7.19E-01
aliphatics	224.3	100	
aromatics	60.1		
Total	284.4		

Table A-41: TPH Fraction RBSLs using MA DEP Protocols for Sample IRP4B14S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
C5-8 Aliphatics	3.4E+01	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	8.1E+01	1.2E+00	1.5E+03	8.6E+01	1.2E-01	4.1E+00
C9-18 Aliphatics	6.8E+01	2.0E+05	1.3E+04	1.3E+11	4.9E+04	9.7E+03	4.9E+04	1.6E+04	1.6E+04	8.4E+05	7.7E+01	1.0E-01	1.0E+01
C19-36 Aliphatics	1.5E-03	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	3.8E+06	No RfC	No RfC	2.0E+02
C9-22 Aromatics	2.9E+02	6.1E+04	3.9E+03	3.2E+10	2.7E+04	3.2E+03	2.7E+04	7.8E+04	1.2E+03	1.9E+03	9.6E+03	3.1E+01	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
C5-8 Aliphatics	2.5E-01	3.4E-01	3.4E-01	1.5E-01	2.6E-04	3.2E-01	2.6E-04	1.6E-01	1.0E+00	8.3E-03	4.8E-03	9.6E-01	1.0E-01
C9-18 Aliphatics	5.2E-01	2.8E-01	2.8E-01	3.2E-01	5.9E-04	3.0E-01	5.9E-04	1.8E-03	1.6E-04	3.4E-05	5.9E-05	4.1E-02	4.1E-04
C19-36 Aliphatics	2.3E-02	6.2E-04	6.2E-04	0.0E+00	0.0E+00	5.4E-04	0.0E+00	0.0E+00	0.0E+00	3.7E-12	0.0E+00	0.0E+00	4.4E-11
C9-22 Aromatics	2.1E-01	3.8E-01	3.8E-01	5.2E-01	2.1E-03	3.7E-01	2.1E-03	7.3E-04	8.7E-04	3.1E-02	1.2E-04	3.1E-03	3.7E-01
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	2.9E-03	1.0E+00	2.9E-03	1.6E-01	1.0E+00	3.9E-02	4.9E-03	1.0E+00	4.7E-01
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.11E+05	7.01E+03	7.88E+10	2.19E+06	5.71E+03	2.19E+06	2.16E+04	4.82E+00	1.77E+03	5.30E+05	4.48E-01	6.67E+00
RBSL(C_{TPH}) (mg/kg)		100000	7000	8E+10	>Csat	6000	>Csat	>Csat	5	>Csat	>S	0.4	>S

Target Risk Level (HI) 1

Use Raoult's Law (Yes/No?) yes

Pathways

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater

Table A-42: TPH Composition Data using MA DEP Protocols for Sample IRP4B15S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME):SANGB POL Area
(LOCATION): RP4B15S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.123	0.0615	1.83E-02	2.35E-04	3.08E-02
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	8.35E-02	3.66E-04	4.79E-02
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.67	0.335	9.99E-02	3.96E-04	5.19E-02
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	8.35E-02	3.31E-04	4.34E-02
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	8.35E-02	3.31E-04	4.34E-02
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	8.35E-02	3.66E-04	4.79E-02
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	8.35E-02	3.00E-04	3.93E-02
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	8.35E-02	3.02E-04	3.96E-02
	TPH fractions							
	C5-C8 aliphatics	9.30E+01		114	114	3.40E+01	3.65E-01	4.79E+01
	C9-C18 aliphatics	1.70E+02		148	148	4.41E+01	2.59E-01	3.40E+01
	C19-C36 aliphatics	3.50E+02	<	13	6.5	1.94E+00	5.54E-03	7.25E-01
	C9-C22 aromatics	1.50E+02		67	67	2.00E+01	1.33E-01	1.74E+01

Total TPH fractions		*Sum of weight %*	7.64E-01
aliphatics	268.5	100	
aromatics	67		
Total	335.5		

Table A-43: TPH Fraction RBSLs using MA DEP Protocols for Sample IRP4B15S5-6P

	C_{csat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
C5C8 Aliphatics	3.4E+01	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	8.1E+01	1.2E+00	1.5E+03	8.6E+01	1.2E-01	4.1E+00
C9-18 Aliphatics	6.8E+01	2.0E+05	1.3E+04	1.3E+11	4.9E+04	9.7E+03	4.9E+04	1.6E+04	1.6E+04	8.4E+05	7.7E+01	1.0E-01	1.0E+01
C19C36 Aliphatics	1.5E-03	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	3.8E+06	No RfC	No RfC	2.0E+02
C9-22 Aromatics	2.9E+02	6.1E+04	3.9E+03	3.2E+10	2.7E+04	3.2E+03	2.7E+04	7.8E+04	1.2E+03	1.9E+03	9.6E+03	3.1E+01	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
C5C8 Aliphatics	3.4E-01	4.3E-01	4.3E-01	2.2E-01	3.3E-04	4.2E-01	3.3E-04	2.0E-01	1.0E+00	1.1E-02	6.1E-03	9.7E-01	1.3E-01
C9-18 Aliphatics	4.4E-01	2.3E-01	2.3E-01	2.8E-01	4.7E-04	2.5E-01	4.7E-04	1.5E-03	9.9E-05	2.7E-05	4.4E-05	3.3E-02	3.3E-04
C19C36 Aliphatics	1.9E-02	4.9E-04	4.9E-04	0.0E+00	0.0E+00	4.3E-04	0.0E+00	0.0E+00	0.0E+00	2.9E-12	0.0E+00	0.0E+00	3.5E-11
C9-22 Aromatics	2.0E-01	3.4E-01	3.4E-01	5.1E-01	1.9E-03	3.4E-01	1.9E-03	6.5E-04	6.1E-04	2.7E-02	1.1E-04	2.1E-03	3.3E-01
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	2.7E-03	1.0E+00	2.7E-03	2.0E-01	1.0E+00	3.8E-02	6.3E-03	1.0E+00	4.6E-01
		TPH Risk Based Screening Levels											
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Tda TPH (mg/kg)		1.04E+05	6.61E+03	8.04E+10	2.19E+06	5.43E+03	2.19E+06	2.16E+04	3.54E+00	1.77E+03	5.30E+05	3.31E-01	6.67E+00
RBSl(C_{TPH}) (mg/kg)		100000	7000	8E+10	>Csat	5000	>Csat	>Csat	4	>Csat	>S	0.3	>S

Target Risk Level (HI) 1

Use Raoll's Law (Yes/No?) yes

Pathways:

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater

Table A-44: TPH Composition Data using MA DEP Protocols for Sample IRP4B16S5-6P

(MM/D/YR): 01/14/03
(TYPE): Soil
(SITE NAME):SANGB POL Area
(LOCATION): RP4B16S5-6P

CAS #	COMPOUND	Molecular Weight (g/mol)	Soil Data (mg/kg)		Calculation (.5* det. Lim.)	Weight percent	(mol/g)	Mole Percent
	Volatile Organic Compounds							
71-43-2	Benzene	7.80E+01	<	0.127	0.0635	3.54E-01	4.54E-03	7.62E-01
	Carcinogenic PAHs							
56-55-3	Benz(a)anthracene	2.28E+02	<	0.56	0.28	1.56E+00	6.84E-03	1.15E+00
50-32-8	Benzo(a)pyrene	2.52E+02	<	0.67	0.335	1.87E+00	7.41E-03	1.24E+00
205-99-2	Benzo(b)fluoranthene	2.52E+02	<	0.56	0.28	1.56E+00	6.19E-03	1.04E+00
207-08-9	Benzo(k)fluoranthene	2.52E+02	<	0.56	0.28	1.56E+00	6.19E-03	1.04E+00
218-01-9	Chrysene	2.28E+02	<	0.56	0.28	1.56E+00	6.84E-03	1.15E+00
53-70-3	Dibenz(ah)anthracene	2.78E+02	<	0.56	0.28	1.56E+00	5.61E-03	9.43E-01
193-39-5	Indeno(123-cd)pyrene	2.76E+02	<	0.56	0.28	1.56E+00	5.65E-03	9.49E-01
	TPH fractions							
	C5-C8 aliphatics	9.30E+01	<	6.5	3.25	1.81E+01	1.95E-01	3.27E+01
	C9-C18 aliphatics	1.70E+02	<	3.4	1.7	9.47E+00	5.57E-02	9.36E+00
	C19-C36 aliphatics	3.50E+02	<	13	6.5	3.62E+01	1.03E-01	1.74E+01
	C9-C22 aromatics	1.50E+02	<	13	6.5	3.62E+01	2.41E-01	4.06E+01

Total TPH fractions		*Sum of weight %*	5.95E-01
aliphatics	11.45	100	
aromatics	6.5		
Total	17.95		

Table A-45: TPH Fraction RBSLs using MA DEP Protocols for Sample IRP4B16S5-6P

	C_{sat} TPH fractions (i) (mg/kg)	Surface Soil Ingestion (mg/kg)	Surface Soil Dermal (mg/kg)	Fugitive Dust Inhalation (mg/kg)	Surface soil Outdoor vapor Inhalation (mg/kg)	Surface soil Soil, Dust, Vapor Combined (mg/kg)	Surface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Outdoor vapor Inhalation (mg/kg)	Subsurface soil Indoor vapor Inhalation (mg/kg)	Subsurface soil Leaching to gw Ingestion (mg/kg)	Groundwater Outdoor vapor Inhalation (mg/L)	Groundwater Indoor vapor Inhalation (mg/L)	Groundwater Ingestion (mg/L)
C5-8 Aliphatics	3.4E+01	8.2E+04	5.2E+03	1.3E+11	4.9E+04	4.4E+03	4.9E+04	8.1E+01	1.2E+00	1.5E+03	8.6E+01	1.2E-01	4.1E+00
C9-18 Aliphatics	6.8E+01	2.0E+05	1.3E+04	1.3E+11	4.9E+04	9.7E+03	4.9E+04	1.6E+04	1.6E+04	8.4E+05	7.7E+01	1.0E-01	1.0E+01
C19-36 Aliphatics	1.5E-03	4.1E+06	2.6E+05	No RfC	No RfC	2.4E+05	No RfC	No RfC	No RfC	3.8E+06	No RfC	No RfC	2.0E+02
C9-22 Aromatics	2.9E+02	6.1E+04	3.9E+03	3.2E+10	2.7E+04	3.2E+03	2.7E+04	7.8E+04	1.2E+03	1.9E+03	9.6E+03	3.1E+01	3.1E+00
	Weight Fraction (f_i) (mg/kg/mg/kg)	Hazard Quotients (HQ_i) for fractions that are calculated iteratively to obtain TPH RBSLs (unitless)											
C5-8 Aliphatics	1.8E-01	2.6E-01	2.6E-01	1.1E-01	2.3E-04	2.5E-01	2.3E-04	1.4E-01	1.0E+00	7.3E-03	4.2E-03	9.8E-01	8.8E-02
C9-18 Aliphatics	9.5E-02	5.3E-02	5.3E-02	5.5E-02	1.3E-04	5.9E-02	1.3E-04	4.0E-04	4.0E-05	7.6E-06	1.2E-05	9.0E-03	9.2E-05
C19-36 Aliphatics	3.6E-01	1.0E-02	1.0E-02	0.0E+00	0.0E+00	9.0E-03	0.0E+00	0.0E+00	0.0E+00	7.0E-11	0.0E+00	0.0E+00	8.5E-10
C9-22 Aromatics	3.6E-01	6.8E-01	6.8E-01	8.4E-01	4.3E-03	6.8E-01	4.3E-03	1.5E-03	2.1E-03	6.3E-02	2.4E-04	7.4E-03	7.7E-01
Total	1.0E+00												
Hazard Index (HI) (ΣHQ_i)		1.0E+00	1.0E+00	1.0E+00	4.7E-03	1.0E+00	4.7E-03	1.4E-01	1.0E+00	7.1E-02	4.4E-03	1.0E+00	8.6E-01
		TPH Risk Based Screening Levels											
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)	(mg/L)
Total TPH (mg/kg)		1.15E+05	7.30E+03	7.36E+10	2.19E+06	6.08E+03	2.19E+06	2.16E+04	6.63E+00	1.77E+03	5.30E+05	6.33E-01	6.67E+00
RBSL(C_{TPH}) (mg/kg)		100000	7000	7E+10	>Csat	6000	>Csat	>Csat	7	>Csat	>S	0.6	>S

Target Risk Level (HI)	1
Use Raoult's Law (Yes/No?)	yes

Pathways

surface soil ingestion = incidental ingestion of surficial soil
surface soil dermal = dermal contact with surficial soil
fugitive dust inhalation = inhalation of dust from surface soil
surface soil outdoor vapor inhalation = outdoor inhalation of vapors from surficial soil
surface soil indoor vapor inhalation = indoor inhalation of vapors from surficial soil
surface soil ingest, dermal, inhal = combined incidential ingestion, inhalation of dust, and outdoor inhalation of vapors from surficial soil
subsurface soil outdoor vapor inhalation =outdoor inhalation of vapors from subsurface soil
subsurface indoor vapor inhalation =indoor inhalation of vapors from subsurface soil
gw outdoor vapor inhalation = outdoor inhalation of vapors from groundwater
gw indoor vapor inhalation =indoor inhalation of vapors from groundwater
gw ingestion = ingestion of groundwater

APPENDIX B

TPH RBSL CALCULATION FORMULAS AND PROCEDURES

The procedure for calculating a TPH RBSL for cross-media pathways based upon summing the risk from each fraction is complex. Please note that the following procedure is only appropriate for calculation of RBSLs for cross-media pathways since it sets as an upper limit for the RBSL the degree of saturation, which does not limit exposure for direct routes such as soil ingestion, dermal exposure, and inhalation of particulates. An additional procedure used to calculate exposure for direct pathways is also provided.

Cross-media Pathways

Partitioning qualities govern how a chemical interacts with its environment. Specific physical properties responsible include solubility, vapor pressure, sorption coefficient and Henry's Law Constant. A brief discussion of the role these parameters play in basic partitioning in the environment is provided in the following paragraphs. The fraction-specific values for each of the described fate and transport parameters is provided in Table B-1. The equations used to develop these fate and transport properties are available in the TPH Criteria Working Group "Volume III. Selection of Representative TPH Fractions Based on Fate and Transport Considerations" (Gustafson *et al.*, 1997).

The solubility of aromatic hydrocarbons, for any EC number, is generally greater than that of aliphatic hydrocarbons, especially at high EC values. The variability in solubility around any given EC value is about an order of magnitude. The higher solubility of the aromatics means that aromatic hydrocarbons are more likely to be present as dissolved constituents in groundwater than are the corresponding aliphatic hydrocarbons.

The soil-water sorption coefficient (k_s) expresses the tendency of a chemical to be adsorbed onto a soil particle. The magnitude of the sorption coefficient for most soil/water systems is a function of the hydrophobicity of the chemical (as indicated by its solubility) and the organic carbon content of the soil. For non-ionic, hydrophobic chemicals such as petroleum hydrocarbons, the primary property controlling sorption is the organic carbon content (f_{oc}) of the soil.

In general, aliphatic fractions are more likely to remain bound to a soil particle than the aromatic fraction of an equivalent EC. This tendency was previously indicated by the low solubility observed for aliphatic fractions. The majority of log k_{oc} (carbon-water sorption coefficient) values presented in Table B-1 were derived from the octanol-water partitioning coefficient (k_{ow}).

There is very little difference in vapor pressure between aliphatic and aromatic constituents of an equivalent EC. In effect, the EC and vapor pressure are closely related. This relationship is expected because both EC and vapor pressure are largely functions of a compound's boiling point.

Table B-1: Hydrocarbon Fractions and Associated Properties

TPH Fractions	Solubility (mg/L)	Henry's Constant (dimensionless)	Vapor Pressure (atm)	Log K_{oc} (c/c)	BP (°C)	MW (g/mole)
Aliphatic						
EC5-6	32	33	0.35	2.9	51	81
EC>6-8	5.4	50	0.063	3.6	96	100
EC>8-10	0.43	80	6.3E-03	4.5	150	130
EC>10-12	0.034	120	6.3E-4	5.4	200	160
EC>12-16	7.6E-4	520	4.8E-5	6.7	260	200
EC>16-21	2.5E-6	4,900	1.1E-6	8.8	320	270
Aromatic						
EC5-7[a]	18E+03	0.23	0.13	1.9	80	78
EC>7-8[b]	520	0.27	0.038	2.4	110	92
EC>8-10	65	0.48	6.3E-03	3.2	150	120
EC>10-12	25	0.14	6.3E-4	3.4	200	130
EC>12-16	5.8	0.053	4.8E-5	3.7	260	150
EC>16-21	0.65	0.013	1.1E-6	4.2	320	190
EC>21-35	0.0066	6.7E-4	4.4E-9	5.1	340	240

[a] benzene, [b] toluene
BP = boiling point, EC = equivalent carbon number, MW = molecular weight
Note: values are based on pure compounds; behavior may differ in complex mixtures

The Henry's law constant (H_c) is definable as an air-water partitioning coefficient and may be measured as the ratio of a compound's concentration in air to its concentration in water at equilibrium. Aliphatics and aromatics behave differently based on Henry's law constant. For aromatic fractions, the Henry's law constant mostly decreases with increasing EC; for aliphatic fractions, the Henry's law constant increases with increasing EC. In general, aliphatic hydrocarbons are less soluble and more volatile than aromatic hydrocarbons. It is important to note, however, that benzene, an aromatic compound, is very volatile and more toxic than the corresponding aliphatic fractions. Therefore, when present, benzene is likely to drive risk calculations for pathways involving volatilization from soil or groundwater.

The parameters described above are combined into simple fate and transport models to evaluate the partitioning and migration of chemicals for the different applicable pathways. For leaching and volatilization pathways where transport and therefore exposure are maximized at the saturation concentration for specific fractions, the following equations are solved. These three equations were adapted from Volume 5 of the Working Group's publications (Vorhees *et al.*, 1999).

$$HI = \sum_{i=1}^{i=n} HQ_i = \sum Min\left(\frac{f_i C_{TPH}}{RBSL_i}, \frac{C_{sat,i}}{RBSL_i}\right) \leq 1 \quad \text{given,} \qquad \text{(Equation B-1)}$$

$$\sum_{i=1}^{i=13} f_i = \sum \frac{C_i}{C_{TPH}} = 1$$ (Equation B-2)

where:

HI	=	Hazard Index (typically ≤ 1) [unitless]
n	=	number of fractions (13 total) [unitless]
HQ_i	=	Hazard Quotient for I^{th} TPH fraction [unitless]
f_i	=	Percent Weight of i^{th} TPH fraction in total TPH mixture [unitless]
C_I	=	Concentration of I^{th} TPH fraction in total TPH mixture [unitless]
C_{TPH}	=	Concentration of TPH mixture
$C_{sat,i}$	=	Saturation concentration for i^{th} TPH fraction (mg/kg)
$RBSL_i$	=	Tier 1 risk-based screening level for i^{th} TPH fraction (mg/kg)

The saturation concentration is defined by Equation B-3:

$$C_{sat,i}[mg/kg] = \frac{S_i}{\rho_s}\left[H_{c,i}\theta_{as} + \theta_{ws} + k_{s,i}\rho_s\right]$$ (Equation B-3)

where:

S_i	=	Fraction effective solubility [mg/L]
ρ_s	=	Soil Bulk Density [g/cm^3]
$H_{c,i}$	=	Henry's Constant for i^{th} TPH fraction [atm-m^3/mol]
θ_{as}	=	Volumetric air content of the soil [cm^3/cm^3]
θ_{ws}	=	Volumetric water content of the soil [cm^3/cm^3]
$k_{s,i}$	=	Soil sorption coefficient for i^{th} TPH fraction (k_{oc}*f_{oc}) [cm^3/g]

Note: The effective solubility of a hydrocarbon fraction is equal to the fraction's solubility limit multiplied by the mole fraction of the hydrocarbon fraction in the mixture (i.e., TPH).

The value obtained for C_{sat} will vary considerably if the effective C_{sat} of each fraction present in the sample is considered through the use of Raoult's law. Equations B1 through B3 are iteratively solved for each TPH fraction, which is the additive mixture RBSL for the soil sample. Residual saturation is the point at which any increase in chemical concentration will not change the risk, up until the point at which free product migration becomes an issue. For purposes of comparing RBSLs obtained using different analytical fractionation methods, such as the MADEP TPH Method, Raoult's law was not used to calculate the RBSLs presented in the following sections.

Soil Leaching to Groundwater Pathway

Leaching of contaminants from impacted soil into groundwater through infiltrating water is one exposure pathway evaluated in the RBCA analysis. Soil RBSLs are calculated to be protective of groundwater quality. This involves: 1) calculating a groundwater RBSL ($RBSL_{gw}$) to determine an acceptable water concentration, 2) calculating a leachate concentration protective of groundwater (based on the groundwater RBSL), and 3) calculating a soil

concentration which would result in this leachate concentration. Equation B4 (adapted from ASTM, 1995) calculates the ingestion $RBSL_{gw}$ for each TPH fraction. The $RBSL_{gw}$ is based on a target hazard quotient of 1.0. Exposure parameters are provided in Table B-2. RfDs for the fractions are listed in Table B-3.

$$RBSL_{gw,i}\left[\frac{mg}{L-water}\right] = \frac{THQ \times RfD_{o,i} \times BW \times AT_n \times 365^{days/yr}}{IR_{water} \times EF \times ED} \qquad \text{(Equation B-4)}$$

where:

THQ	=	Target hazard quotient [unitless] = 1
$RfD_{o,i}$	=	Oral chronic reference dose for i^{th} TPH fraction [mg/kg-day]
BW	=	Body weight [kg]
AT_n	=	Averaging time for noncarcinogens [yrs]
IR_{water}	=	Daily ingestion rate [L/day]
EF	=	Exposure frequency [days/yr]
ED	=	Exposure Duration [yrs]

Table B-2 Tier 1 Default Exposure Factors

Name	Parameter	Units	Recreational Scenario	Commercial Scenario
Averaging Time: non-carcinogens	AT_n	y	25	25
Body Weight	BW	kg	70	70
Exposure Duration	ED	y	30	25
Exposure Frequency	EF	days/y	45	250
Ingestion rate: soil	IR_{soil}	mg/day	50	50
Inhalation Rate: air-indoor	IR_{air-in}	m^3/day	20	20
Inhalation Rate: air-outdoor	$IR_{air-out}$	m^3/day	20	20
Ingestion rate: water	IR_{water}	L/day	0.05	1
Soil Adherence Factor	M	mg/cm^2	0.5	0.5
Dermal Absorption Factor	$RAF_{d,i}$	-	c.s.	c.s.
Oral Absorption Factor	RAF_o	-	1	1
Skin surface area	SA	cm^2/day	3160	3160
Target Hazard Quotient for Individual Constituents.	THQ	-	1	1

Note: c.s. = chemical specific

ED, EF, and IR_{water} for recreational exposure scenario were extracted from http://risk.1sd.ornl.gov/homepage/tm/for_rec_wa.shtml. All other exposure factors for recreational scenario have been set equal to the commercial scenario factors as shown in the above table.

The analytical model used to estimate soil leaching to groundwater determines the partitioning of a constituent into water, vapor and sorbed phases based on the physical and chemical properties of the constituent. In this model, infiltrating water migrates through contaminated soils in the vadose zone. At this point, some of the contaminant partitions from

the soil or vapor transfer into the water phase. This leachate is then assumed to migrate completely and instantaneously into groundwater. Some dilution of the leachate is included using an attenuation factor based on infiltration rate, groundwater velocity, source width and height of the mixing zone in the water column. Equation B-5 describes this attenuation factor (AF).

Table B-3: TPHCWG Toxicity Fraction-Specific RfDs (mg/kg/day)*

Carbon Range	Aromatic RfD	Critical Effect	Aliphatic RfD	Critical Effect
EC5-6 EC>6-8	0.20 – Oral** 0.4 – Inhalation**	Hepatotoxicity, Nephrotoxicity	5.0 – Oral 18.4 - Inhalation	Nephrotoxicity, Hepatotoxicity, Neurotoxicity
EC>8-10 EC>10-12 EC>12-16	0.04 – Oral 0.2 – Inhalation	Decreased body weight	0.1 - Oral 1.0 – Inhalation	Hepatic and hematological changes
EC>16-21 EC>21-35	0.03 - Oral NA - Inhalation	Nephrotoxicity	2.00 NA - Inhalation	Hepatic granuloma (foreign body reaction)

Note: NA = not applicable
* Vorhees *et al.*, 1999.
** Excludes EC5-6 as benzene noncancer toxicity was under review by USEPA at the time of publication*

$$AF = \left[1 + \frac{U_{gw}\delta_{gw}}{IW}\right] \qquad \text{(Equation B-5)}$$

where:
U_{gw} = Groundwater velocity [ft/day]
δ_{gw} = Height of groundwater mixing zone [ft]
I = Precipitation infiltration rate [ft/day]
W = Width of the source area parallel to the mixing zone [ft]

Partitioning into the three phases, soil, water and air, is governed by the partitioning factor. As Henry's law constant is applicable only to dilute solutions, the use of this model is not appropriate when free phase liquid is present. The partitioning factor (PF) for each TPH fraction is shown in Equation B-6.

$$PF_i = \frac{\left[\theta_{ws} + k_{s,i}\rho_s + H_{c,i}\theta_{as}\right]}{\rho_s} \qquad \text{(Equation B-6)}$$

where,

θ_{ws}	=	Soil volumetric water content [cm^3/cm^3]
$k_{s,i}$	=	Soil sorption coefficient (k_{oc}*f_{oc}) for i^{th} TPH fraction [cm^3/g]
ρ_s	=	Soil density [g/cm^3]
$H_{c,i}$	=	Henry's Constant for i^{th} TPH fraction [atm-m^3/mol]
θ_{as}	=	Soil volumetric air content [cm^3/cm^3]

The inverse of the product of PF multiplied by AF, which accounts for dilution of leached water into underlying groundwater, is termed the soil to water leaching factor (LF_{sw}). The ultra-conservative leaching model assumes that no attenuation of leachate occurs from the vadose to the saturated zone. In fact, biological degradation of the constituent or repartitioning onto soil or into the vapor phase are all likely to occur as the leachate migrates to groundwater. Other assumptions of the model include: 1) a constant chemical concentration in the subsurface soils, 2) linear equilibrium partitioning within the soil matrix between sorbed, dissolved and vapor phases, 3) steady-state leaching from the vadose zone to groundwater, and 4) steady state, well-mixed dispersion of the leachate within the groundwater mixing zone. Therefore the LF_{sw}, which governs the movement of contaminants from soil to infiltrating water, incorporates both the PF and the AF, in Equation B-7:

$$LF_{sw,i} = \frac{\rho_s}{\left[\theta_{ws} + k_{s,i} + H_{c,i}\theta_{as}\right]\left(1 + \frac{U_{gw}\delta_{gw}}{IW}\right)} \qquad \text{(Equation B-7)}$$

where:

$LF_{sw,i}$	=	leaching factor for i^{th} TPH fraction [mg/L-H_2O / mg/kg-soil]
ρ_s	=	Soil Bulk Density [g/cm^3]
θ_{ws}	=	Soil volumetric water content [cm^3/cm^3]
$k_{s,i}$	=	Soil sorption coefficient (k_{oc}*f_{oc}) for i^{th} TPH fraction [cm^3/g]
$H_{c,i}$	=	Henry's Constant for i^{th} TPH fraction [atm-m^3/mol]
θ_{as}	=	Soil volumetric air content [cm^3/cm^3]
U_{gw}	=	Groundwater Darcy velocity [ft/day]
δ_{gw}	=	Height of groundwater mixing zone [ft]
I	=	Precipitation infiltration rate [ft/day]
W	=	Width of source area parallel to wind direction [cm]

Parameters for cross-media pathways are provided in Table B-4. Equations B-5 through B-8 were adapted from ASTM's risk-based corrective action (RBCA) standard guide (1995). Once the LF has been established, fraction-specific soil RBSLs may be calculated as follows:

$$RBSL_{s,i}\left[\frac{mg}{kg-soil}\right] = \frac{RBSL_{gw,i}\left[\frac{mg}{L-air}\right]}{LF_{sw,i}} \qquad \text{(Equation B-8)}$$

Volatilization to Indoor Air Pathway

The mathematical model used to estimate volatilization from soil to indoor air is based upon the partitioning of a constituent into water, vapor and sorbed phases as determined by the physical properties of the chemical. The model accounts for the contaminant partitioning into soil pore gas and migrating through the vadose zone to the base of a building foundation. From there the gas diffuses through cracks in the foundation and into the building air space, where exposure through inhalation may occur.

The first step in calculating a soil RBSL for the indoor air pathway requires the calculation of an air concentration or RBSL, which is protective of indoor air quality (based on a target HQ of 1.0). Indoor air RBSLs are calculated for each TPH fraction and then a whole TPH RBSL is calculated based on the percent composition of each fraction. Equation B-9 is used to calculate the air RBSLs for TPH fractions. Parameter values are presented in Table B-4.

Table B-4 Parameters for Cross-Media RBSL Calculations

Description	Parameter	Units	Tier 1 Default Values
Ambient air mixing zone height	δ_{air}	cm	200
Areal fraction of cracks in foundations/walls	η	cm^2/cm^2	0.01
Depth to subsurface soil sources	L_S	cm	100
Diffusion coefficient in air	D^{air}_i	cm^2/s	c.s.
Diffusion coefficient in water	D^{wat}_i	cm^2/s	c.s.
Enclosed space air exchange rate	ER	1/s	0.00023
Enclosed space foundation or wall thickness	L_{crack}	cm	15
Enclosed space volume/infiltration area ratio	$L_{B,i}$	cm	300
Fraction of organic carbon in soil	f_{oc}	cm^3/cm^3	0.01
Groundwater Darcy velocity	U_{gw}	cm/yr	2500
Groundwater mixing zone thickness	δ_{gw}	cm	200
Henry's Law Constant	$H_{c,i}$	(cm^3/cm^3)	c.s.
Infiltration rate of water through soil	I	cm/yr	30
Particulate Emission Rate	$VF_{p,i}$	$\frac{(mg/m^3)}{(mg/kg)}$	6.9×10^{-14}
Soil bulk density	ρ_s	g/cm^3	1.7
Soil-water sorption coefficient	$k_{s,i}$	cm^3/g	$f_{oc} \times k_{oc}$
Total soil porosity	θ_T	cm^3/cm^3	0.38
Volatilization Factor (Vapor Emission Rate)	$VF_{ss,i}$	$\frac{(mg/m^3)}{(mg/m^3)}$	0.26
Volumetic air content in vadose zone soils	θ_{as}	cm^3/cm^3	0.26
Volumetric air content in foundation cracks	θ_{acrack}	cm^3/cm^3	0.26
Volumetric water content vadose zone soils	θ_{ws}	cm^3/cm^3	0.12
Volumetric water content: foundation cracks	θ_{wcrack}	cm^3/cm^3	0.12
Width of source area parallel to flow direction	W	cm	1500
Wind speed above ground surface	U_{air}	cm/s	225

Notes: c.s. = chemical specific
m.s. = media specific
Commercial/Industrial Scenario

$$RBSL_{air,i}\left[\frac{\mu g}{m^3 air}\right] = \frac{THQ \times RfD_{i,i} \times BW \times AT_n \times 365\,{}^{days}/_{yr} \times 10^3\,{}^{\mu g}/_{mg}}{IR_{air} \times EF \times ED}$$

(Equation B-9)

where:

THQ	=	Target hazard quotient [unitless] = 1
$RfD_{i,i}$	=	Inhalation chronic reference dose for i^{th} TPH fraction [mg/kg-day]
BW	=	Body weight [kg]
AT_n	=	Averaging time for noncarcinogens [yrs]
IR_{air}	=	Daily inhalation rate [m^3/day]
EF	=	Exposure frequency [days/yr]
ED	=	Exposure Duration [years]

The second step in calculating a soil concentration ($RBSL_{soil}$) which will result in an acceptable indoor air concentration ($RBSL_{air}$) is to model the transport of contaminants from the vadose soil to indoor air. This model is extremely conservative, assuming: 1) a constant chemical concentration in subsurface soils; 2) linear equilibrium partitioning in the soil between sorbed, dissolved and vapor phases; and 3) steady-state vapor- and liquid-phase diffusion through the vadose zone and foundation cracks. In addition, the model assumes that vapors migrate completely and instantaneously into the building, i.e., no attentuation occurs. It does not account for any biodegradation and soil sorption which could occur as the vapor migrates through the vadose zone.

Dilution of vapor is expected to occur between the source and the building. Therefore the following diffusion coefficient in soil (D^{eff}_s) for each TPH fraction is used (see Equation B-10).

$$D_{s,i}^{eff}\left[\frac{cm^2}{s}\right] = D_i^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D_i^{wat}\frac{1}{H_{c,i}} \times \frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

(Equation B-10)

where:

D^{air}_i	=	Diffusion coefficient in air for i^{th} TPH fraction [cm^2/sec]
θ_{as}	=	Soil volumetric air content [cm^3-air/cm^3-soil]
θ_T	=	Total soil porosity [cm^3/cm^3]
D^{wat}_i	=	Diffusion coefficient in water for i^{th} TPH fraction [cm^2/sec]
$H_{c,i}$	=	Henry's constant for i^{th} TPH fraction [cm^3-air/cm^3-soil]
θ_{ws}	=	Soil volumetric water content [cm^3-water/cm^3-soil]

The diffusion of the pore gas through cracks in the foundation is governed by Equation B-11. Equations B-9 through B-11 were adapted from ASTM RBCA (1995).

$$D^{eff}_{crack,i}\left[\frac{cm^2}{s}\right] = D^{air}_i \frac{\theta^{3.33}_{acrack}}{\theta^2_T} + D^{wat}_i \frac{1}{H_{c,i}} \times \frac{\theta^{3.33}_{wcrack}}{\theta^2_T}$$ (Equation B-11)

where:

D^{air}_i = Diffusion coefficient in air for i^{th} TPH fraction [cm^2/sec]
θ_{acrack} = Volumetric air content in foundation [cm^3-air/cm^3]
θ_T = Total soil porosity [cm^3/cm^3]
D^{wat}_i = Diffusion coefficient in water for i^{th} TPH fraction [cm^2/sec]
$H_{c,i}$ = Henry's constant for i^{th} TPH fraction [cm^3-air/cm^3-soil]
θ_{wcrack} = Volumetric water content in foundation [cm^3-water/cm^3]

Chemical Partitioning

Equation B-12 accounts for the movement of chemicals from the soil into the vapor phase of the soil pore space. This is defined as the partitioning factor (soil/vapor phase) and is fraction specific.

$$PF_{s-v,i} = \frac{H_{c,i}\rho_s}{\theta_{ws} + k_{s,i}\rho_s + H_{c,i}\theta_{as}}$$ (Equation B-12)

where:

$PF_{s-v,i}$ = Soil/Vapor phase partitioning factor for i^{th} TPH fraction [unitless]
$H_{c,i}$ = Henry's Constant for i^{th} TPH fraction [cm^3-water/cm^3-air]
ρ_s = Soil bulk density [g/cm^3]
θ_{ws} = Soil volumetric water content [cm^3/cm^3]
$k_{s,i}$ = Soil sorption coefficient (k_{oc}*f_{oc}) for i^{th} TPH fraction [cm^3/g]
θ_{as} = Soil volumetric air content [cm^3/cm^3]

The diffusion coefficients and partitioning factor are combined to yield a subsurface soil to enclosed space volatilization factor (VF_{sesp}) for each TPH fraction. VF_{sesp} takes into account partitioning, diffusion in the vadose zone, effective diffusion into an enclosed space and adds terms for accumulation of vapors in the enclosed space (see Equation B-13).

$$VF_{sesp,i} = \frac{(PF_{s-v,i})\dfrac{D^{eff}_{s,i}/L_s}{ER \times L_B}}{1 + \dfrac{D^{eff}_{s,i}/L_s}{ER \times L_B} + \dfrac{D^{eff}_{s,i} + L_s}{(D^{eff}_{crack,i}/L_{crack}) \times \eta}} \times 10^3 \left[\frac{cm^3 - kg}{m^3 - g}\right]$$ (Equation B-13)

where:

$PF_{s-v,i}$ = Soil/Vapor phase partitioning factor for i^{th} TPH fraction [unitless]
$D^{eff}_{s,i}$ = Effective diffusion coefficient in soil for i^{th} TPH fraction [cm^2/s]
L_s = Depth to subsurface soil sources [cm]
ER = Enclosed-space air exchange rate [s^{-1}]
L_B = Enclosed-space volume/infiltration area ratio [cm]

$D^{eff}_{crack,i}$ = Effective diffusion coefficient through foundation cracks for i^{th} TPH fraction [cm^2/s]
L_{crack} = Enclosed-space foundation or wall thickness [cm]
η = Areal fraction of cracks in foundation/walls [cm^2/cm^2]

Values in these calculations are provided in Table B-4. The term VF_{sesp}, when combined with the allowable concentration of contaminant in the air space ($RBSL_{air}$), determines the maximum allowable concentration in the subsurface soil source area for each TPH fraction. The RBSL for the volatilization to indoor air pathway ($RBSL_{svin}$) is shown in Equation B-14. Equations B-12 through B-14 were adapted from ASTM RBCA (1995).

$$RBSL_{svin,i}\left[\frac{mg}{kg-soil}\right]=\frac{RBSL_{air,i}\left[\frac{mg}{m^c-air}\right]}{VF_{sesp,i}} \qquad \text{(Equation B-14)}$$

Volatilization to Outdoor Air Pathway

The volatilization to outdoor air model is similar to the indoor air model. It assumes contaminants partition into soil pore gas that migrates through the vadose zone to the surface and mixes with the ambient air. Dispersion into ambient air is modeled using a "box model", which is typically valid for source widths of less than 100 feet parallel to wind direction. Steady-state well-mixed atmospheric dispersion of the vapors within the breathing zone is assumed. Other assumptions listed for the indoor air model include linear equilibrium partitioning, steady-state vapor diffusion through the vadose zone and no attenuation of the chemical as it migrates through the vadose zone.

The calculation of a soil RBSL protective of outdoor air quality is similar to that used for the indoor air pathway. A volatilization factor for ambient air (VF_{samb}) is derived for each fraction, using the same effective diffusion coefficient in vadose soils and partitioning factor. Equations B-15 and B-16 were adapted from ASTM RBCA (1995). Default values are provided in Table B-4.

$$VF_{samb,i}\left[\frac{mg/m^3-air}{mg/kg-soil}\right]=\frac{PF_{s-v,i}}{1+\frac{U_{air}\delta_{air}L_s}{D^{eff}_{s,i}W}}\times 10^3\left[\frac{cm^3-kg}{m^3-g}\right] \qquad \text{(Equation B-15)}$$

where:
$PF_{s\text{-}v,i}$ = Soil/Vapor phase partitioning factor for i^{th} TPH fraction [unitless]
U_{air} = Wind speed above ground surface in ambient mixing zone [cm/s]
δ_{air} = Ambient air mixing zone height [cm]
L_s = Depth to subsurface soil sources [cm]
$D^{eff}_{s,i}$ = Effective diffusion coefficient in soil for i^{th} TPH fraction [cm^2/s]
W = Width of source area parallel to wind direction [cm]

VF_{samb} is then combined with the allowable concentration of contaminant in the air space ($RBSL_{air}$) to determine the maximum allowable concentration of contaminant in the subsurface soil for each fraction. This concentration, $RBSL_{svout}$, is defined by Equation B-16.

$$RBSL_{svout,i} = \frac{RBSL_{air,i}\left[\frac{mg}{m^e-air}\right]}{VF_{samb,i}} \qquad \text{(Equation B-16)}$$

Direct Contact Pathway

For direct exposure routes to soil such as ingestion, dermal absorption and inhalation of particulates, exposure is not limited by C_{sat}. The assumption is made that intake will continue to increase linearly with soil loading beyond C_{sat}. For the direct contact pathways, the Equations B-17 and B-18 are solved (adapted from Vorhees *et al.*, 1999 and ASTM, 1995, respectively).

$$HI = \sum_{i=1}^{i=n} HQ_i = \sum_{i=1}^{i=n} \frac{fiC_{TPH}}{RBSL_i} \leq 1 \qquad \text{(Equation B-17)}$$

$$RBSL_{ss,i}\left[\frac{ug}{kg-soil}\right] = \frac{THQ \times BW \times AT_n \times 365^{days}/_{yr}}{EF \times ED \times \left[\frac{10^{-6\ kg}/_{mg} \times (IR_{soil} \times RAF_{o,i} \times SA \times M \times RAF_{d,i})}{RfD_{o,i}}\right] + \left[\frac{IR_{air} \times (VF_{ss,i} + VF_{p,i})}{RfD_{i,i}}\right]}$$

(Equation B-18)

where:

THQ	=	Target hazard quotient for constituent [unitless]
BW	=	Body weight [kg]
AT_n	=	Averaging time for noncarcinogens [years]
EF	=	Exposure frequency (days/year]
ED	=	Exposure duration [years]
IR_{soil}	=	Soil ingestion rate [mg/day]
$RAF_{o,i}$	=	Relative oral absorption factor for i^{th} TPH fraction [unitless]
SA	=	Skin surface area [cm^2/day]
M	=	Soil to skin adherence factor [mg/cm^2]
$RAF_{d,i}$	=	Relative dermal absorption factor for i^{th} TPH fraction [unitless]
$RfD_{o,i}$	=	Oral chronic reference dose for i^{th} TPH fraction [mg/kg-day]
IR_{air}	=	Inhalation rate [m^3/day]
$VF_{ss,i}$	=	Surficial soils to ambient air partition factor (vapor) for i^{th} TPH fraction [unitless]
$VF_{p,i}$	=	Surficial soils to ambient air partition factor (particulates) for i^{th} TPH fraction [unitless]
$RfD_{i,i}$	=	Inhalation chronic reference dose for i^{th} TPH fraction [mg/kg-day]

Similar to the HI calculation, the RBSL equation is solved iteratively to find C_{TPH} such that HI is under the constraint of a target hazard index of 1.0. Default exposure parameters are provided in Table B-2. The fraction specific RfDs are provided in Table B-3.

REFERENCES

ASTM. 1995. Standard Guide for Risk-based Corrective Action Applied at Petroleum Release Sites. E-1739-95. American Society for Testing and Materials, West Conshohocken, PA.

Gustafson, J.B., Griffith-Tell, J., Orem, D. 1997. Total Petroleum Hydrocarbon Criteria Working Group Series, Volume 3: Selection of Representative TPH Fractions Based on Fate and Transport Considerations. Amherst Scientific Publishers, Amherst, MA. 137 p.

Vorhees, D., Gustafson, J., Weisman, W. 1999. Total Petroleum Hydrocarbon Criteria Working Group Series, Volume 5: Human Health Risk-based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach. Amherst Scientific Publishers, Amherst, MA. 98 p.

APPENDIX C:

FIELD DEMONSTRATION SAMPLE LOG AND PHOTOGRAPHS OF SAMPLING EQUIPMENT AND SITE SAMPLING ACTIVITIES

TPHCWG Demonstration
IRP Site 4, POL Area
Springfield ANG Base
Springfield, Ohio

Table C-1:Field Sample Log for IRP Site 4, SANGB Base, 9 Dec 02

Conditions (re: WPAFB @ 12:00 noon): Temp = 28°F, B.P. 775 mm Hg, wind 10 mph from South, R.H. 56%						
Soil Boring/ Sample Number	Location	Depth (bgs)	PID (ppm)	Soil appearance	Zone Sampled	Remarks
IRP4B01	26' N of Sump	0.5	0	clayey		Full core recovery
"		1.5	0			
"		2.5	0			
"		3	0			
"		3.5	0			
"		4	2			
" S4-5P		4.5	30	gray/grainy	4 to 5 feet bgs	bag reading 18.2
"		5	3			time ~ 0950
"		5.5	0			
"		6	0			
IRP4B02	31' N of Sump	0.5	0	grayer/clayey		
"		5	10 to 13			"stinky"
" S5-6P		5.5	130 to 140		5 to 6 feet bgs	bag reading 76
"		6	N.R.			time ~ 10:18
IRP4B03	36' N of Sump	2	0	clayey, non-consol.		incomplete core
"		3	0			
"		3.5	12	some rock		
"		4	30			
" S5-6P		5	250 to 374	"stinky", no staining	5 to 6 feet bgs	bag reading 446
"		5.5	70			time ~ 11:06
		6.5	N.R.	silty clay		collected 3rd core
IRP4B04	5' E of IRP4B01	0.5	0	clayey		
"		3	10.2			
"		3.5	13.5			
"		4	49			
"		4.5	186.7	"stinky" - intermittent		bag reading 62
" S5-6P		5	216	coincided with silty	5 to 6 feet bgs	time ~ 11:38
"		5.5	1	gray material		
"		6	N.R.			
IRP4B05	10' E of IRP4B01	0.5	0	clayey		
"		3.5	1	no odor		
"		4	1.2			finding not
"		4.5	1.5			consistent with
"		5	2.9	silty sandy lens	no sample taken	previous
"		5.5	4.3	very wet		investigations
"		6	N.R.			
IRP4B06	15' E of IRP4B01	0.5	0	clayey & rocks		
"		3.5	0	"		
"		6	0			
"		6.5	0		no sample taken	only 2' recovery
"		8	N.R.	silty & sandy		in soil core
IRP4B07	21' N of Sump	1.5	0	clayey		time ~ 13:40
"	(5' S of IRP4B01)	2	0			
"		2.5	0			
"		3	8	rock		
"		3.5	1.4			
"		4	2.2			
"		4.5	3.8	wet zone	no sample taken	
"		5	15			
"		5.5	7.2 to 26			
"		6	42			
IRP4B08	5' W of IRP4B01	2	0	rock at 0.5 feet		
"		2.5	0			
"		3	0			
"		3.5	59			
"		4	237			
"		4.5	488 to 610			
"		5	736			
" S5-6P		5.5	1041	staining and product	5 to 6 feet bgs	bag reading 538

Soil Boring/ Sample Number	Location	Depth (bgs)	PID (ppm)	Soil appearance	Zone Sampled	Remarks
IRP4B08	5' W of IRP4B01	6	1287			time ~ 14:15
"		6.5	180 to 264			
"		7	45			
"		7.5	N.R.			only 2.5' recovery
IRP4B09	10' W of IRP4B01	3	0			
"		3.5	19			
"		4	30			
"		4.5	132	clay		
"		5	409			
" S5-6P		5.5	61		5 to 6 feet bgs	bag reading 82
"		6	214			time ~ 14:45
"		6.5	31			
"		7	9	limestone		
IRP4B10	5' W of IRP4B01	5	277	clay		field duplicate
" S5-6P		5.5	478		5 to 6 feet bgs	bag reading 414
"		6	243	quartz layer		time ~ 15:03
IRP4B11	15' W of IRP4B01	3	0 to 20			
"		3.5	35			
"		4	75			
"		4.5	179			
"		5	66			
"		5.5	32		no sample taken	
"		6	5.75			
IRP4B12	5' N & 5' W of B01	0.5	0			
"		1	3			
"		1.5	3	clayey & rocks		
"		2	4.1			
"		2.5	6.5			
"		3	10.5			
"		3.5	98.5 to 196			
IRP4B12	5' N & 5' W of B01	4	175			
"		4.5	134 to 375			
"		5	419	stone		
" S5-6P		5.5	415	gray staining	5 to 6 feet bgs	bag reading 551
"		6	N.R.	"stinky"		time ~ 15:37
IRP4B13	10' N & 10' W of B01	2	0			
"		2.5	2	clay & gravel	no sample taken	
"		3	N.R.			
IRP4B14	15' N of IRP4B01	0.5	0			
"		3.5	14	clayey		
"		4	59.6			
"		4.5	201			
" S5-6P		5	356		5 to 6 feet bgs	bag reading 243
"		5.5	100			time ~ 16:10
"		6	0	sandy		
IRP4B15	5' N & 5' E of B01	0.5	0			
"		3.5	32			
"		4	78			
"		4.5	328	gray staining		
" S5-6P		5	330	in middle, "stinky"	5 to 6 feet bgs	bag reading 436
"		5.5	336			time ~ 16:35
"		6	N.R.			
IRP4B16		3	0			background sample
"		3.5	0			
"		4	0	silty layer		
"		4.5	0	very wet		
" S5-6BK		5	0	heavy clay	4 to 6 feet bgs	bag reading 0
"		5.5	0			
"		6	0			

Note: N.R. = Not Recorded

Table C-2: Field Sample Summary for IRP Site 4, SANGB, 9 Dec 02

WX conditions (re: WPAFB @ 12:00 noon): Temp = 28°F, B.P. 775 mm Hg, wind 10 mph from South, R.H. 56%							
Soil Boring / Sample Number		Location	Depth (bgs)[1]	PID (ppm) (max. val.)[2]	Soil appearance	Zone Sampled	Composite headspace PID reading (ppm)[3]
IRP4B01	S4-5P	26' N of Sump	4.5	30	gray/grainy	4 to 5 feet bgs	18.2
IRP4B02	S5-6P	31' N of Sump	5.5	140	grayer/clayey	5 to 6 feet bgs	76
IRP4B03	S5-6P	36' N of Sump	5	374	silty clay, "stinky"	5 to 6 feet bgs	446
IRP4B04	S5-6P	5' E of IRP4B01	5	216	silty, gray, "stinky"	5 to 6 feet bgs	62
IRP4B08	S5-6P	5' W of IRP4B01	5.5	1287	staining and product	5 to 6 feet bgs	538
IRP4B09	S5-6P	10' W of IRP4B01	5.5	409	limestone	5 to 6 feet bgs	82
IRP4B10	S5-6P	5' W of IRP4B01	5.5	478	quartz layer	5 to 6 feet bgs	414
IRP4B12	S5-6P	5' N & 5' W of B01	5.5	419	gray, stains, "stinky"	5 to 6 feet bgs	551
IRP4B14	S5-6P	15' N of IRP4B01	5	356	sandy	5 to 6 feet bgs	243
IRP4B15	S5-6P	5' N & 5' E of B01	5	336	gray, stains, "stinky"	5 to 6 feet bgs	436
Average			5.2	404.5			286.6

[1] Depth in feet below ground surface (bgs)

[2] Maximum photoionization detector (PID) reading obtained in sampling zone (ppm)

[3] Headspace reading of soil core composite in 1-gallon Ziplock™ bag

Table C-3: Field Log for QA/QC Samples at IRP Site 4, SANGB, 9 Dec 02

QC Sample Number	Type Sample	Equipment	Remarks
IRP4RB01	Rinsate	Trowel	Decontamination station rinsate blank collected during morning sampling
IRP4RB02	Rinsate	S.S. Bowl	Decontamination station rinsate blank collected during afternoon sampling
IRP4DW01	DW	N/A	Distilled water sample from final rinse water source

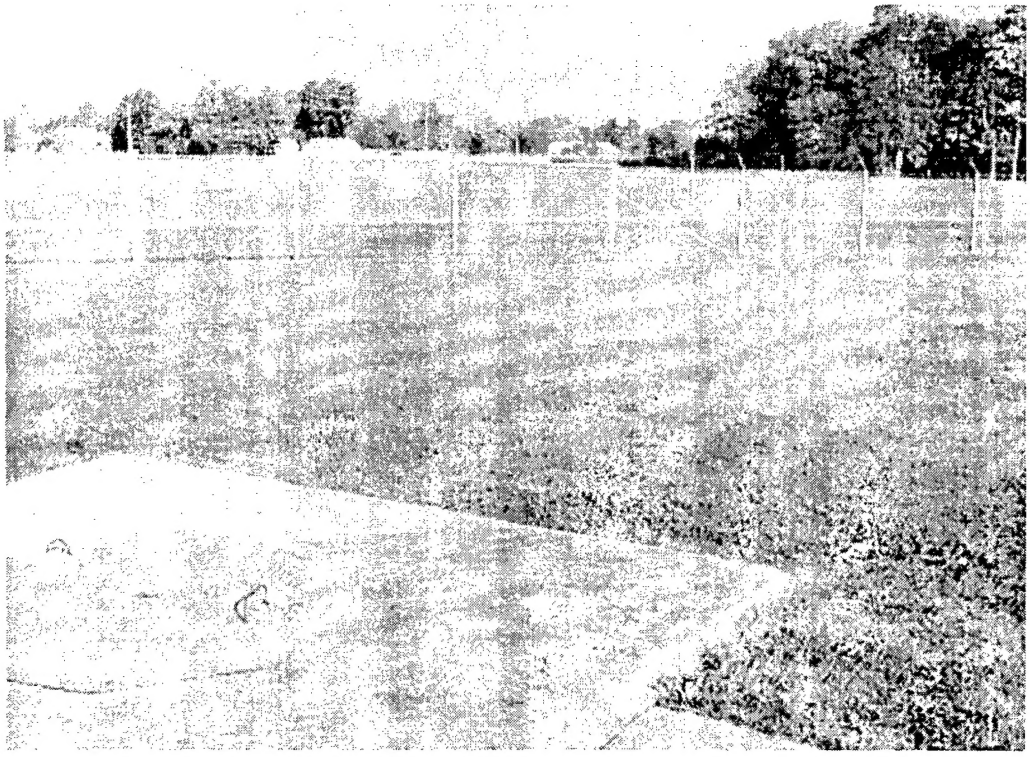

Figure C-1: SANGB POL Area
Photo taken from pump station (block 115 on Figure 2-1) toward the monitoring well (MW 4-1, Figure 2-1), which is not visible in the photo.

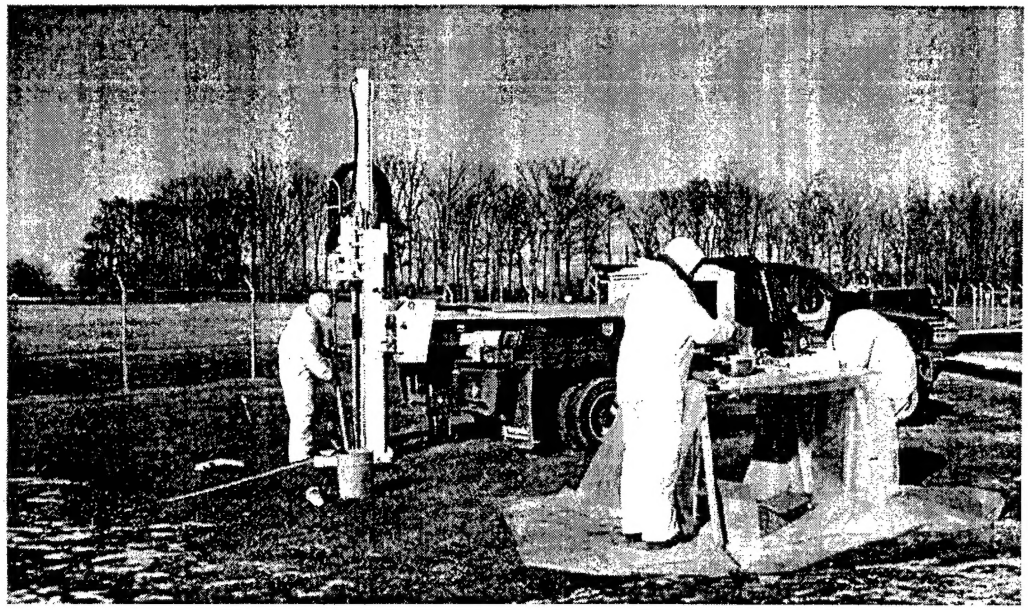

Figure C-2: Sampling Team